NATIONAL INTELLIGENCE SURVEY

U.S.S.R.

FUELS

FEBRUARY 1969

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This Section 62F and Section 62P, dated June 1968, supersede Section 62, dated September 1963, copies of which should be destroyed.

FIGURES

This section was prepared for the NIS by the Central Intelligence Agency.

Fuels

A. General

1. Energy position

a. Production and consumption — The U.S.S.R. ranks second among the nations of the world in the total production and consumption of primary energy,[1] being surpassed only by the United States. In 1967 the production of primary energy in the U.S.S.R. was equivalent to about 1.1 billion tons [2] of standard fuel.[3] Of that amount, deducting net exports, approximately 1 billion tons were available for national consumption. The principal sources of primary energy—coal, oil, and natural gas—accounted for about 90% of the total available for consumption in 1967. In the United States, the estimated consumption of primary energy from these major sources in 1967 was about 2.1 billion tons of standard fuel. The per capita consumption of energy in 1967 was about 11 tons of standard fuel in the United States and only about 4 tons in the U.S.S.R. The estimated consumption of primary energy from principal sources in 1967 by the U.S.S.R. and the United States is shown below, in million tons of standard fuel and in percent:

	U.S.S.R.		United States	
	Quantity	Percent	Quantity	Percent
Coal	416	*46*	480	*23*
Oil	301	*33*	824	*39*
Natural gas	186	*21*	792	*38*
	902	*100*	2,096	*100*

During 1959-67, production of primary energy in the U.S.S.R. rose about 76%, or at an average annual rate of 6.5%. During this period significant changes occurred in the contribution to total energy output by the major fuels—coal, oil, and natural gas. The share of natural gas in primary energy production increased from about 5% in 1958 to almost 17% in 1967, and that of oil rose from about 25% to almost 37% during the same years. The share of coal, on the other hand, declined from nearly 57% in 1958 to about 38% in 1967. Coal lost its predominant position in 1961 when for the first time it furnished less than half of total energy output. Details of production and apparent consumption of primary energy in the U.S.S.R. in 1958 and 1967 are shown in Figure 1. 25X1

The U.S.S.R. is the world's leading producer and consumer of peat, oil shale, and fuelwood, but these low-grade fuels contributed less than 6% of total energy produced and consumed in 1967. The combined contribution of hydroelectric and nuclear power to total primary energy output and use was less than 4% in 1967.

b. Major developments — The most important development in the fuels industries of the U.S.S.R. during 1959-67 has been the increasing importance of petroleum and the diminishing role of solid fuels in the energy balance. The petroleum-solid fuels relationship throughout this period has been analagous in most respects to that which prevailed in the United States in the 1940's when coal was gradually supplanted by petroleum as the major source of energy. It is likely that in the U.S.S.R., as has happened in the United States, coal eventually may be used primarily for making coke and for generating electric power, whereas petroleum will satisfy the bulk of the fuel requirements. This trend continued in 1968 when 594 million tons of coal, 309 million tons of crude oil, and 171 billion cubic meters of natural gas were produced.

Several changes in economic policy have influenced developments in the coal industry since 1958. A major change called for a reduction in investment during the early 1960's as it was anticipated that prolific deposits of oil and gas could be exploited rapidly and that these fuels would replace the more expensive solid fuels. The shift to petroleum, however, did not take place as quickly as planned and as a result increased investments were authorized during 1964-67 for long-term coal mining projects. A major problem exists in coal mining because of the rising costs for adding new production capacity and for replacing older and simpler mining equipment with more modern items. The recent change in the pricing system has resulted in significant increases in coal prices in an attempt to operate the industry on a profitable basis and to eliminate the large subsidies of the past.

The Soviet petroleum industry not only has met and overfulfilled plans for the production of crude oil during 1959-67, but also has provided a steadily rising surplus of oil for export, much of which has been sold in Free World markets. During 1965-67 oil exported to the West was the largest single earner of

[1] Includes energy derived from coal, crude oil, natural gas, hydroelectric power, nuclear power, peat, oil shale, and fuelwood.

[2] Tonnages are reported in metric tons throughout this section.

[3] Standard fuel is defined as containing 7,000 kilocalories per kilogram.

FIGURE 1. ESTIMATED PRODUCTION AND APPARENT CONSUMPTION OF PRIMARY ENERGY

ENERGY SOURCE	UNITS	PRODUCTION	IMPORTS*	EXPORTS*	NET SUPPLY	STANDARD FUEL**		PERCENT OF TOTAL	
						Production	Apparent consumption	Production	Apparent consumption
					1958	- - - *Million tons* - - -			
Solid fuels:									
Coal	Million metric tons	493.2	4.5	12.4	485.3	362.1	356.3	*56.7*	*58.2*
Peat	*do*	53.3	0	0	53.3	21.1	21.1	*3.3*	*3.4*
Oil shale	*do*	13.2	0	0	13.2	4.5	4.5	*0.7*	*0.7*
Fuelwood	Million cubic meters	124.1	0	0	124.1	32.9	32.9	*5.2*	*5.4*
Total, solid fuels						420.6	414.8	*65.9*	*67.7*
Petroleum:									
Crude oil	Million metric tons	113.2	4.3	18.1	99.4	161.9	142.2	*25.3*	*23.2*
Natural gas	Billion cubic meters	28.1	0	0.2	27.9	33.9	33.6	*5.3*	*5.5*
Total, petroleum						195.8	175.8	*30.6*	*28.7*
Power:									
Hydroelectric	Billion kilowatt-hours	46.5	0	*Insig*	46.5	22.3	22.3	*3.5*	*3.6*
Nuclear	*do*	*na*	0	0	0	*Insig*	0	*0*	*0*
Total, power						22.3	22.3	*3.5*	*3.6*
Grand total						638.7	612.9	*100.0*	*100.0*
					1967				
Solid fuels:									
Coal	Million metric tons	595.2	8.5	26.0	577.7	428.6	416.0	*38.1*	*41.7*
Peat	*do*	60.2	0	0	60.2	22.4	22.4	*2.0*	*2.2*
Oil shale	*do*	21.6	0	0	21.6	7.5	7.5	*0.7*	*0.7*
Fuelwood	Million cubic meters	96.1	0	0	96.1	30.6	30.6	*2.7*	*3.1*
Total, solid fuels						489.1	476.5	*43.5*	*47.7*
Petroleum:									
Crude oil	Million metric tons	288.1	1.4	78.8	210.7	411.9	301.2	*36.6*	*30.1*
Natural gas	Billion cubic meters	157.4	0.5	1.3	156.6	187.4	186.4	*16.6*	*18.6*
Total, petroleum						599.3	487.6	*53.2*	*48.7*
Power:									
Hydroelectric	Billion kilowatt-hours	88.6	*Insig*	1.8	86.8	34.9	34.2	*3.1*	*3.4*
Nuclear	*do*	5.0	0	0	5.0	2.0	2.0	*0.2*	*0.2*
Total, power						36.9	36.2	*3.3*	*3.6*
Grand total						1,125.3	1,000.3	*100.0*	*100.0*

na Data not available.

*Adjusted for secondary forms such as coke and petroleum products.

**Standard fuel contains 7,000 kilocalories per kilogram.

25X1

foreign exchange, used to buy Western equipment and technology for developing Soviet industry. The U.S.S.R. also provides about 85% of the total oil supplies of the Communist countries of Eastern Europe, excluding Rumania. The major tasks confronting the oil industry are: development of extensive crude oil deposits in remote areas of Siberia; and construction of secondary refining facilities to vary the mix and improve the quality of petroleum products.

Production and consumption of natural gas during the past 9 years rose faster than production and consumption of energy from any other source. Despite the almost five-fold increase in output during this period, most of the annual goals were not fulfilled because of the failure to produce and/or install equipment for transport and consumption of gas. These problems recently led to downward revision of the production goal for 1970.

2. Organization and plan

In 1965 a system of centralized control by industrial ministries was instituted in place of the relatively decentralized industrial administration initiated in 1957. The organization of industry reverted almost to that which existed before 1957. The sovnarkhozy or Councils of National Economy, which had operated each of the industrial and construction enterprises within specified geographic domains since 1957, were replaced by 23 industrial ministries. Included in the organizational changes were increased authority for management at the enterprise level and a reduction in the number of the plan targets centrally assigned to the enterprises.

Of the major fuels industries in the U.S.S.R. only the gas industry is administered by an All-Union Ministry, which directly controls the operational units without intervening levels of administration at the Republic level. Other segments of the fuels industries—coal and oil—are controlled by Union Republic Ministries with administrative elements interposed between the national ministries and the various operating enterprises. The most important administrative organs in the coal industry at the Republic level are the combines and trusts of the R.S.F.S.R., the Ministry of the Coal Industry of the Ukrainian S.S.R., and the Administration of the Coal Industry of the Kazakh S.S.R.

Responsibility for guiding the oil industry is shared by the Union Republic Ministries of the Petroleum Extraction Industry and of the Petroleum Refining and Petrochemical Industry. The Ministry of Petroleum Extraction is responsible for all drilling o 25X1 tions, exploratory and developmental, for both oil and gas industries. On the other hand, the Ministry of the Gas Industry controls the equipping of new fields, carrying out secondary recovery programs, and constructing pipelines and storage facilities for both oil and gas. The operation of petroleum refineries, the output of petroleum products, and the production of chemicals from petroleum feedstocks (including all rubber and rubber processing) are controlled by the Ministry of Petroleum Refining and Petrochemical Industry. Basic organizational features of the fuels industries and related industries within the governmental structure of the U.S.S.R. are shown in Figure 2.

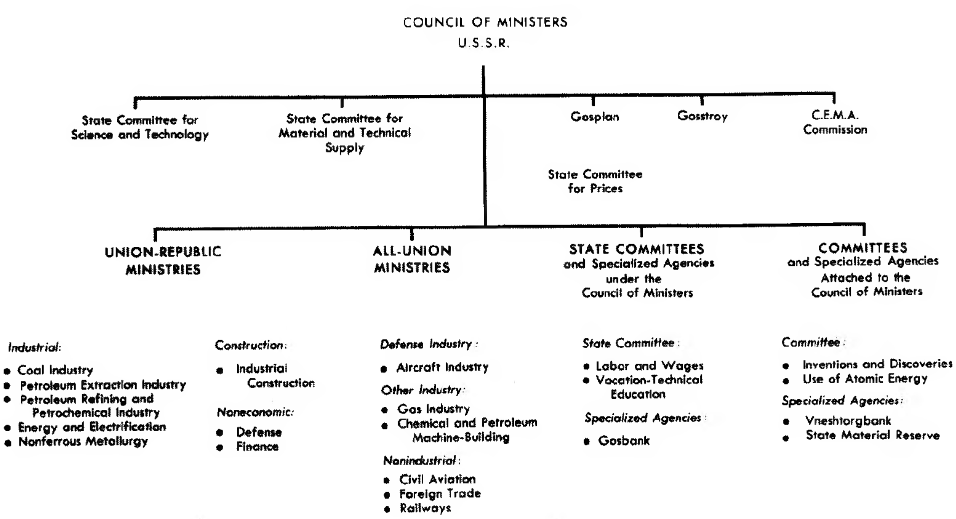


FIGURE 2. ORGANIZATIONAL FEATURES OF THE FUELS INDUSTRIES IN THE U.S.S.R. (U/OU)

FIGURE 3. PRODUCTION GOALS FOR MAJOR FUELS ([redacted] 25X1

FUEL	UNITS	PLANNED GOALS		TENTATIVE GOALS	
		1969	1970	1975	1980
Coal*	Million tons	595.3	665–675	900	1,200
Crude oil	....*do*	326.5	350	450–470	600–620
Natural gas**	Billion cubic meters	185.8	215	340–360	570–720

*Subsequent statements by high officials of the coal industry indicate that the 1970 goal may have been revised downward to 622.5 million tons and that of 1975 to 700 million tons. If these changes are confirmed, the 1980 goal also will probably be revised.

**Including minor amounts of manufactured gas.

The current Five Year Plan (1966-70) calls for vigorous development of the major fuels industries in the U.S.S.R., including a preferential policy for growth in output of oil and gas and for increasing their share in the national supply of primary energy. Major resources of fuels have been discovered east of the Ural Mountains and production in this area will become increasingly important. It is planned that by 1970 the regions east of the Urals will supply 45% of the total output of coal, about one-third of the natural gas and one-sixth of the crude oil produced in the U.S.S.R. By 1980 the corresponding percentages of national output to be supplied by these regions are: 50% for coal, 65% for natural gas, and up to 40% for crude oil. Available data on planned output of the major fuels in the U.S.S.R. for 1969, 1970, 1975, and 1980 are shown in Figure 3.

Coal industry plans call for greater emphasis on the production of coking coal for metallurgical uses, and of low-cost strip mined coal, chiefly for the generation of electric power. Underground mines will become much larger in size and are to be supplied with the most modern equipment. The labor force of individual mines will be concentrated at fewer and wider working faces. Increases in production are to be accomplished mainly by increasing labor productivity through intensive mechanization, with an ultimate goal of complete automation. More effort will be devoted to reconstructing and reequipping existing underground mines and less on constructing new mines. Expected increases in production from strip mining will come from gigantic open pits now in the initial stage of development or planned for 1970-75.

Petroleum industry plans call for expanding the production base in the eastern regions by locating new reserves of oil and gas. This is to be accomplished by improving exploration capabilities through use of advanced technology, particularly in seismic work and deep-drilling. Shortages of equipment at the wellhead are to be overcome by an improved supply system. The gas and oil pipeline network will be expanded with the aim of considerably reducing the transport of oil by rail.

A rapid improvement in the technical level of refining equipment is called for. Emphasis will be on secondary refining to increase the variety of the product mix and to upgrade product quality. The sulfur content of diesel fuels is to be lowered and the octane rating of motor gasolines is to be increased.

3. Investment [redacted] 25X1

Figure 4 shows estimated and planned productive investment [4] in the major fuels industries of the U.S.S.R. for periods from 1952 through 1970.

During 1959-65, productive investment in the coal, oil, and natural gas industries of the U.S.S.R. was planned at about 25 billion rubles.[5] Of that total about 13 billion rubles were planned for the oil industry, including almost 4 billion for oil refining and petrochemicals and 2 billion for construction of oil and gas pipelines; about 8 billion rubles for the coal industry; and approximately 4 billion for the gas industry. Actual investments in these industries during this seven-year period were estimated at 22.5 billion rubles, or about 90% of plan. Investment in these fuels industries represented about 22% of total investment in industry of all types. Compared to the previous seven-year period (1952-58), investment in the petroleum industry during 1959-65 more than doubled while that for the coal

[4] Excludes investment not directly associated with production such as investment in housing for workers, schools, etc.

[5] About US$28 billion at the official rate of exchange (1 ruble = $1.11).

FIGURE 4. ESTIMATED AND PLANNED PRODUCTIVE INVESTMENT IN THE MAJOR FUELS INDUSTRIES [redacted] 25X1
(*Billions of constant rubles*)

INDUSTRY	1952–58	1959–65	1961–65	1966–70 PLAN
Oil	*6.2	5.9	4.8	3.6
Oil refining and petrochemicals	....	3.7	3.3	6.6
Total oil	6.2	9.6	8.1	10.2
Gas	1.0	3.0	2.2	5.9
Pipeline construction	....	**2.7	**2.1	2.3
Total petroleum	7.2	15.3	12.4	18.4
Coal	6.1	7.2	5.2	7.2
Total	13.3	22.5	17.6	25.6

*Includes oil extraction, refining and petrochemicals, storage, and pipeline construction.

**Includes relatively minor but unknown amounts for water pipelines.

industry rose only about 18%, indicating the relative emphasis placed on expansion of production and distribution of oil and gas.

In the course of the present Five Year Plan (1966-70), total productive investment in these major fuels industries is to reach almost 26 billion rubles, and again will represent about 22% of total industrial investment. Although there probably will be little or no change in the total share of these fuels industries in national industrial investment compared to the 1961-65 plan period, some noticeable shifts in allocations to individual sectors of these industries is apparent. For example, planned investments in the oil refining and petrochemicals industry are to be double those actually allocated during 1961-65, as a result of a greater effort in the construction of high-cost petrochemical plants and of secondary oil refining facilities. Productive investment in the gas industry, excluding pipeline construction, is planned to rise by 168% compared to the 1961-65 plan period. This represents an attempt to compensate for the past record of shortfalls in planned output.

4. Costs and prices

In the U.S.S.R. oil and gas are providing an increasingly larger share of the output of primary energy because, for most uses, they are cleaner, easier to transport and use, more efficient, and cheaper than coal. In some areas remote from producing centers of the major fuels, lower quality local fuels, such as peat and fuelwood, are used to avoid transport costs. In certain industrial processes, such as making coke from coal, specific primary fuels are required regardless of their relative cost.

During 1959-65 the average cost of 1 ton of standard fuel in the Soviet Union declined by 24%. This achievement was due primarily to the increased use of lower cost petroleum which more than offset the effect of increased coal costs. The average cost of production of natural gas declined almost 42% and that of crude oil was reduced about 17% while the average production cost in the coal industry rose more than 15% during this seven-year period.

The estimated average cost of production of the major fuels in the U.S.S.R. in 1966, in rubles per natural unit and rubles per ton of standard fuel, are shown as follows:

	Rubles/ton	Rubles/ton of standard fuel
Coal	8.69	12.1
Crude oil	2.76	1.9
Natural gas	*0.45	0.4

* Rubles/1,000 cubic meters.

As shown in the tabulation, the average cost per ton of standard fuel for natural gas was only 3% of that of coal and the average cost of production of crude oil was 16% of the cost of coal. These costs, however, do not include expenditures for geological and exploratory work. Thus the true average costs are understated to a greater extent for production of oil and gas than for coal, as geological-exploratory costs for these fuels normally are much higher than those for coal.

The price reforms instituted in 1967 have changed costs of fuel production, but the full extent of the changes is unknown. The average cost of production in the coal industry for the first 3 quarters of 1967 was reported as 12.24 rubles per ton, an increase of about 41% over costs in 1966. The increase was attributed mainly to the higher cost of materials and to the inclusion of interest charges for capital. As far as is known, geological-exploratory costs and rent payments were not included in the new cost of production for coal. In the petroleum industry, however, geological-exploratory costs and rent payments became chargeable to the cost of production, as are interest on capital and the rise in the cost of materials. In the oil industry the new chargeable cost of geological-exploration work varies according to region from 0.35 ruble to 3.8 rubles per ton of crude oil, and rent payments range from 0.7 ruble to 14 ruble ton of crude oil. Corresponding charges in the natural gas industry are 1 ruble per 1,000 cubic meters for exploratory work and 2.15 rubles to 12 rubles per 1,000 cubic meters for rent. The new average costs of production of crude oil and natural gas are not available at this time.

The greatest change of the new reforms has been in the price system for fuels. Prior to the reforms the coal industry was operating at a substantial annual loss. One intent of the reforms was to make it profitable. In line with this aim, the average wholesale price of coal was raised 78%, including an increase of 93% for coking coal and 70% for general purpose coal. Retail prices for household users, however, were not increased. Although about 30% to 40% of the total number of coal mines are still operating at a loss, the industry as a whole now is showing a profit of 8% to 9%.

The Soviet petroleum industry, which has always been profitable, is even more so since the price reforms. Total profits in oil extraction, oil processing, and the gas industries rose from 359 million rubles in 1958 to 957 million rubles in 1965 and accounted for about 4% of total industrial profits during this period. After the reforms the average increases in the wholesale prices of crude oil and natural gas rose 130% and 51%, respectively. As in the coal industry, retail prices were not increased, and the principal effect of the price changes has been to raise costs and profits in the industrial sector of the economy.

B. Solid fuels

1. Introduction (C)

The U.S.S.R. is the world's foremost producer of solid fuels, ranking first in the output of coal, coke, peat (used as fuel), and fuelwood; second in the ex-

traction of oil shale; and third in the production of fuel briquettes. In 1967 the U.S.S.R. produced 595 million tons of coal, 70 million tons of coke, 60 million tons of fuel peat, about 22 million tons of oil shale, 96 million cubic meters of fuelwood, and about 10 million tons of fuel briquettes. Coal, the major solid fuel, accounted for about 42% of the apparent consumption of primary energy in the U.S.S.R. in 1967. Preliminary reports for 1968 indicate that 594 million tons of coal were mined.

The Soviet Union ranks third among the countries of the world as an exporter of coal, and second as an exporter of coke. Net exports in 1967 amounted to 14.5 million tons of coal and 3 million tons of coke. Soviet coal is vital to the Communist countries of Eastern Europe, both for fuel and for making metallurgical coke. Approximately 65% of the coal and coke exported by the U.S.S.R. went to other Communist countries and the remainder to non-Communist countries in 1967.

The U.S.S.R. claims to have the largest coal reserves in the world, about 8.7 trillion tons. However, only 3% of this tremendous total is considered to be proved reserves, whereas 86% is classified as possible. More than 90% of the total reserves are located east of the Urals, far from the more heavily populated and industrialized western areas. The eastern coals are only fair to average in quality; about two-thirds of these reserves are classified as low-rank bituminous and brown coals.

The western coal deposits are generally of better quality, but even they have deficiencies. For example, coking coal produced in the Donets basin, the major source of such coal, has a sulfur content of more than 2%, which necessitates blending with higher quality coal prior to use in the metallurgical industry. The western deposits also are more costly to mine due to difficult geological conditions. These factors have made it feasible in certain areas to exploit cheap local sources of fuel such as peat and oil shale.

Prior to 1967 the price of most coal was deliberately set below the cost of production, and the necessary state subsidy to the industry grew year by year. In 1967 as a result of a general price reform the average wholesale price of coal was raised by 78% and the average cost of production was increased by more than 40%. The net effect of these changes was to make the coal industry profitable.

Although coal is being replaced as a fuel by oil and gas in various industrial sectors, present plans call for a continuing growth of coal production. An ambitious program of reequipping the industry with modern machinery and equipment has been underway for several years. The new equipment is to raise labor productivity and to reduce labor cost. The plans for expansion are aimed chiefly at increasing the output of coking coal and of low-cost strip-mined coal in the eastern regions.

2. (UNC

25X1CODE

a. Reserves — According to official estimates, completed in 1956, the total (actual, probable, and possible) reserves of coal in the U.S.S.R. amounted to 8.67 trillion tons. In a more realistic appraisal made in 1958, based on the permissible minimum seam thickness and maximum ash content standards of the coal industry, total reserves of coal were estimated at 7.76 trillion tons. Comparison with the total reserves of other countries may be misleading because of differences in standards; nevertheless, the U.S.S.R. is one of the world's major possessors of coal reserves. Principal Soviet coal basins and deposits are shown on Figure 74.

Reserves are divided into groups by degree of exploration, by depth, and by type of coal (degree of metamorphism). Significantly, actual and probable reserves comprise only 3% and 11%, respectively, of the total reserves. Lack of sufficiently reliable information with respect to the deeper and more remote deposits accounts for the high proportion (86%) in the category of possible reserves. It should also be noted that the data do not include numerous coal-bearing areas, such as those found in the northeast of the U.S.S.R. and parts of Western Siberia, and only partly include reserves of such vast coal regions as the Lena and Tungus basins in Eastern Siberia.

The 1956 estimate of reserves included coal to a depth of 1,800 meters and in seams which exceed 0.4 meter in thickness for hard coals (anthracite and bituminous) and 0.5 meter for brown coals. Moreover, coals with an ash content as high as 50% were included. There were also certain exceptions in applying the standards, such as in the central part of the Donets basin where seams of 0.3 meter thickness are included and in the Moscow basin where coals with an ash content of up to 60% are included. Over half the reserves are at depths exceeding 600 meters and 20% are at depths between 1,200 and 1,800 meters. It is only within the Donets and Kizel basins that development at depths beyond 1,000 meters has been started. For the majority of other basins and coal fields of interest, maximum current operating depths are no more than 300 to 600 meters. The official estimates of coal reserves as of 1957 are tabulated in Figure 38.

Coal is classified in several ways in the U.S.S.R. In Figure 38, the classification is divided into 6 groups, based on the degree of metamorphism. The 6 groups and their respective shares in the total reserves are as follows (in percent):

Anthracite and lean coals (A&T)	*12.5*
Bituminous coals (PS, K and PZh)	*22.5*
Bituminous, gas coals (G)	*9.5*
Bituminous, long-flame coals (D)	*15.3*
Transition coals, from hard to brown (DB)	*5.5*
Brown coals (B)	*34.7*
Total	*100.0*

Coals suitable for coking are included in groups PS, K, PZh and G. A considerable part of the coal reserves in these two groups, however, is unacceptable for making metallurgical coke because of one or more unfavorable characteristics—high ash content, high sulfur content, resistance to cleaning, and weakly caking or non-caking properties.

Although over-all reserves of coal are tremendous and deposits are scattered throughout the U.S.S.R., the regions east of the Urals have 93% of the total reserves, of which 55% are located north of 60° north latitude in Krasnoyarskiy Kray and Yakutskaya A.S.S.R. In the western (European) regions of the country and the Urals, deposits of better quality coal are limited almost entirely to the Donets, Pechora, and Kizel basins. Production from these three basins has not satisfied requirements and as a result the western regions consume large quantities of low-grade fuels such as brown coal, peat, and oil shale. Considerable coal is also imported from the Karaganda and Kuznetsk basins to the east. Coal from these eastern sources must be transported long distances—up to 3,700 kilometers—to serve major consuming centers. The blast furnaces of the Urals iron and steel industry, for example, are almost entirely dependent on coke made from coal hauled 1,100 kilometers from Karaganda and more than 2,000 kilometers from the Kuznetsk basin.

b. Deposits — Five basins provided about two-thirds of the total coal produced in the U.S.S.R. in 1966. The major characteristics of these basins are discussed in the succeeding paragraphs.

(1) *The Donets basin* — The Donets basin is located in the Donetskaya, Luganskaya and Dnepropetrovskaya Oblasts of the eastern Ukraine and Rostovskaya Oblast' of the R.S.F.S.R. The basin as presently delineated, extends 600 kilometers from east to west, varies in width from 70 to 170 kilometers, and covers an area of about 60,000 square kilometers. The discovery of large coal-bearing areas west, east, and north of the old boundaries of the basin are mainly responsible for an increase in the estimate of reserves from 89 billion tons in 1937 to about 241 billion tons in 1956. As of 1956, anthracite coals constituted 39% of the reserves and gas type bituminous coals accounted for 27%. Only 13% of the reserves were of the varieties—PS, K, and PZh—most suitable for coking purposes. Actually, there is a shortage of low-sulphur, low-volatile bituminous coal of type PS which is needed to blend with other types for coking.

About 105 of the 250 coal seams found in the basin are considered minable, with a thickness of more than 0.45 meter. The average thickness of all seams being worked is 0.7 meter, but most of the production comes from seams of about 1 meter in thickness. The seams are highly folded with a general inclination of 10 to 20 degrees, but in some mines seams with a pitch of more than 50 degrees are worked. More than half of all the mines are working thin seams at depths of 300 to 600 meters. Approximately 13% of all the mines are working at depths of more than 600 meters and some mines have reached working depths of 1,000 to 1,100 meters. Donets mines are relatively dry, but are very gassy. In about one-third of the seams being worked the emission of ethane is more than 15 cubic meters per ton of coal mined.

(2) *The Kuznetsk basin* — The Kuznetsk basin, with reserves estimated at 900 billion tons, is one of the largest coal basins in the world. It is located in Western Siberia, almost entirely within the limits of Kemerovskaya Oblast', and covers an area of 26,700 square kilometers. The basin is about 300 kilometers long northwest-southeast and about 100 kilometers wide. The region is in the basins of the Tom' and Inya rivers, tributaries of the Ob' river, and is largely covered by forests.

Kuznetsk coals are characterized by low ash and sulfur content and are generally higher in quality than any other coals found in the U.S.S.R. Although more than a third of the reserves are suitable for coking, there is a relative scarcity of one type (PZh) needed for blending, a lack which represents a serious problem.

There are about 85 workable seams, including some that attain a thickness of from 8 to 18 meters. The average thickness of the seams being mined was about 2.1 meters and about 22% of the output was from seams exceeding 6.5 meters in thickness in recent years. However, approximately half of the production was from steeply pitching seams (as much as 70 degrees), located in the Prokop'yevsk-Kiselevsk coking coal region. In the southern part of the Kuzbass, some thick seams have been found near the surface in the Tom-Usinsk district which can be strip mined on a large scale. Figure 5 shows a typical underground mine in the Kuznetsk basin.

(3) *The Moscow basin* — The Moscow basin extends over an area of about 120,000 square kilometers and contains 25 to 35 lenticular beds of brown coal, interspersed in some places with thin lenses of higher grade cannel or boghead coal. The quality of the brown coal is impaired by a high content of both moisture and ash. Reserves are estimated at 24 billion tons. Practically all of the mines are in the southern wing of the basin which covers an area of 70,000 square kilometers and is located south of the Smolensk-Gzhatsk railroad line. The seams, where mined, average about 2.1 to 2.3 meters in thickness, although they may attain a thickness of 4 meters locally. They lie almost horizontally under a shallow cover of 25 to 70 meters. Underground mining is hampered by unstable roof conditions, "karst holes," and considerable ground water. An average of 7 cubic meters of water was pumped per ton of coal mined. Some strip mining has been started on shallow coal seams in Kimovskiy

FIGURE 5. UNDERGROUND COAL MINE IN THE KUZNETSK BASIN

25X1

and Bogoroditskiy Rayons of Tul'skaya Oblast' and in Gorlovskiy Rayon of Ryasan'skaya Oblast'.

(4) *The Karaganda basin* — The Karaganda basin, located in east central Kazakhstan, has a coal-bearing area of 2,000 square kilometers and ranks third in the U.S.S.R. as a producer of hard coal. Reserves estimated at 51 billion tons, consist almost entirely of bituminous coals suitable for making coke. About a fourth of the output, however, consists of brown coal from a strip mine exploiting a thick seam in the Mikhaylov deposit. There are 58 bituminous seams in the basin, ranging from 0.5 to 8 meters in thickness. About one-third of the shaft mines worked seams at depths of 50 to 200 meters while the other two-thirds operated at depths of less than 300 meters. Because of their high content of impurities, most of the Karaganda coals require intensive cleaning before they can be used for coking. The Churub Nura and Tenlek areas have large reserves of coking coal which are relatively low in ash and sulfur content.

(5) *The Pechora basin* — The Pechora basin, despite its remoteness and the severe climate, has been developed into one of the major sources of coal in the U.S.S.R. Among the factors contributing to its development were the completion of the railroad to Vorkuta in 1941, the proximity to European consuming centers, and the relatively good quality of its coals. About a third of the reserves are suitable for coking (PS, K, and PZh). The total area of the basin is about 120,000 square kilometers and reserves are estimated at about 344 billion tons. The coal seams which are worked range from 0.5 to 4.5 meters in thickness and their pitch is usually between 15 and 40 degrees. The bulk of the coal is mined at Vorkuta, but some coal is also mined at Inta, Kozhim, Yedzhid-Kyryinskoye, and Khal'mer-yu.

(6) *Other deposits* — Present policies call for greater emphasis on the strip mining of coal because of its low cost compared to underground mining. The bulk of the reserves suitable for stripping, however, are located in the Eastern Regions and are mostly low quality coals. Due to their low quality, these coals cannot be shipped economically for any great distance and plans have been made to utilize them locally for the generation of electric power. The electric power, in turn, is to be transmitted to the distant European consumption centers. Attention has been focused on two deposits, the Kansk-Achinsk basin in Eastern Siberia and the Ekibastuz deposit in Kazakh S.S.R.

The Kansk-Achinsk basin, located along the Trans-Siberian Railroad from the city of Mariinsk to Tayshet, is 700 kilometers long and from 100 to 300 kilometers wide. Total possible reserves were estimated at 1.2 trillion tons, including 100 billion tons that can be strip mined. The coal is better-than-average ,brown coal with about 50% volatile matter, a moisture content of 33% to 38%, a calorific value ranging as high as 3,800 kilocalories per kilogram, and an ash content of 4.7% to 9.5%. Seams average from 12 meters to 15 meters in thickness while the overburden ratio for strippable coal varies from 0.8 to 6 cubic meters of cover per ton of coal.

The Ekibastuz deposit is located in Pavlodarskaya Oblast' in the Kazakh S.S.R. The deposit is in a deep basin about 25 kilometers long and 9 kilometers wide. Total possible reserves were estimated at 12.2 billion tons in 1956. The 1958 evaluation based on the standards of the mining industry cut the estimate of total reserves to 10.7 billion tons, probably because of poor quality characteristics, but all of the coal is considered strippable. There are three major seams with an average thickness of 118 to 120 meters where they merge into each other. The seams consist of intermixed layers of coal and rock of variable thicknesses. Because of the rock, ash content can run as high as 45% to 50%. The coal is low grade bituminous, type SS (weakly caking), and, as shipped, has 8% moisture, a low sulfur content, about 40% ash content, and a calorific value of about 4,000 kilocalories per kilogram. An additional bad characteristic is the frequent fluctuation in ash content; variations of as much as 20% have been reported.

The planned program for accelerating strip mined production at Kansk-Achinsk and Ekibastuz and using the coal for generating electric power has been hampered by several factors. Among these are the lack of modern stripping machinery and special combustion and handling equipment which can utilize low-quality coal efficiently. In 1966 and 1967 local electric powerplants rejected large amounts of coal from both basins because of poor quality and thus prevented fulfillment of the mines' production plans. Also the proposed

giant-sized powerplants and the transmission lines to carry electric power have not yet been constructed. In early 1968, it was stated by a member of GOSPLAN that the rate of development of the Kansk-Achinsk basin could not be raised until the problem of transmitting electric power to the European regions by ultra-high voltage lines had been solved.

c. PRODUCTION — Although the fuels policy of the U.S.S.R. emphasizes increasing the share of natural gas and crude oil in the fuel balance, coal will continue to play an important role. Despite its diminishing share in the total output of fuels, the production of coal will increase, although at a slower rate than contemplated in previous plans. From World War II through 1958 the output of coal increased annually by an average of 26.7 million tons a year. The Seven Year Plan (1959-65) provided for a growth of only 16.8 million tons per year.

In 1958, the U.S.S.R. attained first place among the coal producing nations of the world, displacing the United States, which had held this position since 1899. In 1967, Soviet output of coal reached 595 million tons, about 84 million tons more than United States output. However, because of the lower quality of Soviet coal, the total calorific value of the United States output was about 23% greater than that of U.S.S.R. in 1967.

The Seven Year Plan (1959-65) called for the production of 600-612 million tons of coal in 1965. Instead of a gain of about 110 million tons during these years, the actual increase was about 84.5 million tons. The goals of the Seven Year Plan apparently were abandoned, as in each year the annual goal was substantially less than that of the original plan. The Eighth Five Year Plan (1966-70), stipulates that the Soviet coal industry is to produce 665-675 million tons in 1970. However, the yearly planned goals have been regularly revised downward and it appears that the control figures for 1970 will not be attained. Total production in 1968 was 594 million tons while the annual plan for 1969 is about 595 million tons. The goal of 670 million tons for 1970 appears too optimistic; its achievement would require increases of approximately 38 million tons a year for 1969 and 1970, a feat not accomplished since 1956.

After World War II coal production shifted back to the pre-war pattern whereby the western regions and the Urals accounted for most of the production. In 1958, the western regions and the Urals produced 65% of the coal mined in the U.S.S.R. By 1965 this share had fallen to about 61%, and 39% of the total output came from the eastern regions. During 1959-66, output of coal in the western regions increased about 10%, in the Urals it declined slightly, and in the eastern regions it increased almost 39%. In the western regions the Donets basin and the Pechora basin increased their outputs but production in the Moscow basin declined, as did that of the Urals region. The declines in production of the Moscow basin and the Urals region probably reflect a policy of phasing-out high cost producers in those areas. In the eastern regions, the biggest increases were registered by the Kazakh S.S.R. with 53%, the Far East region with about 50%, and the Kuznetsk basin with about 33%. Figure 39, provides detailed information on the regional pattern of output.

Of the total coal mined in the U.S.S.R. in 1967, approximately 63% (374 million tons) was bituminous, 24% (144 million tons) was brown coal, and about 13% (77 million tons) was anthracite. During 1958-67, total production of coal increased by almost 21%, that of anthracite and bituminous by about 4% and 34% respectively, and production of brown coal increased by 2.6%. Production of the various types of coal in selected years is shown as follows, in millions of tons:

YEAR	BITUMINOUS	ANTHRACITE	BROWN	TOTAL
1958	278.8	74.2	140.2	493.2
1960	300.8	74.1	134.7	509.6
1965	351.4	76.5	149.8	577.7
1966	362.4	76.8	146.4	585.6
1967	374.2	77.1	143.8	595.2

A more detailed breakdown of Soviet coal production is given in Figure 40.

Practically all of the anthracite is mined in the Donets basin; the remaining minor quantity is produced in the Urals from the Yegorshino deposit. Production of bituminous coal is more widely dispersed with most of the output coming from the Donets, Pechora, and L'vov-Volyn basins in the western region, the Kizel basin in the Urals region, and the Karaganda, Kuznetsk, and Irkutsk basins in the eastern regions.

Coking coal averaged about 40% of the total bituminous output during 1963-67, compared to 34% in 1958. Production of the best type of coking coal (K-Koksovyy) is very small, however, and according to data from the Donets and Kuznetsk basins, the two major producers, production has been practically constant at 44-45 million tons a year during 1958-65. To offset the sparse supply of K coals and the high sulfur content of the Donets coals (up to 2.5% sulfur) the U.S.S.R. blends different types of coal on a wide scale. In recent years, even minor amounts of weakly caking (G-Gazovyy) and non-caking (D-Dlinnoplamennyy) type coals have been used. The major sources of coking coal for the years 1958-65 are shown in Figure 41.

d. QUALITY AND PREPARATION — The U.S.S.R. mines all types of coal, but the average quality of the total output is inferior to that of the United States. The average calorific value of Soviet coals in 1967 was about 5,040 kilocalories per kilogram, compared with an approximate calorific value of 7,220 kilocalories per kilogram for U.S. coal. The lower average calorific value of Soviet coals results from a com-

paratively higher proportion of brown coal in total output (24%) and higher average ash content.

The calorific value of Soviet coals, on an as received basis, ranges from as high as 8,100 kilocalories per kilogram for the highest quality Kuznetsk coals to about 1,600 kilocalories per kilogram for the poorest grade of Ukrainian brown coal. In 1958, the average calorific value of coal from major basins was as follows:

	KILOCALORIES PER KILOGRAM
Donets	6,100
Kuznetsk	6,400
Moscow	2,600
Karaganda	5,400
Pechora	5,600

Brown coal has a high moisture content which is normally in the range of 25% to 35%, although Ukrainian and Bashkir brown coals contain as much as 55% moisture. In general, brown coal in the Asiatic U.S.S.R. is of better quality than that found in the European U.S.S.R. Some brown coal is cleaned mechanically in the U.S.S.R. and some is processed to make briquettes, but the amounts are unknown. Ordinarily, brown coal does not store well as it disintegrates into dust on exposure to the weather and also is very susceptible to spontaneous combustion. Brown coal is generally used soon after it is mined, chiefly at local power stations.

There are no known national Soviet standards for the classification of coal. The two systems most generally used are those for coals of the Donets and Kuznetsk basins. These systems are based mainly on the volatile matter content and caking properties of the coal. Available information on these two classification systems is summarized in Figure 42. The general size classification and nomenclature for Soviet coals is shown in Figure 43.

The most important quality deficiencies of Soviet coals are high ash and sulfur content. The ash content has increased somewhat in recent years as a result of exploitation of seams with higher ash content and the inclusion of more extraneous rock as a result of increased mechanized mining. The increase in mechanized mining is also responsible for the bigger share of fines in the raw coal output. Fines are inherently more difficult to clean than the lump sizes. The share of all coal mined in the U.S.S.R. which was mechanically cleaned has increased from about 25% in 1958 to almost 40% in 1967. The yield of clean coal, however, declined from about 63% of the coal processed in 1958 to 61% in 1967. Coking coal comprised about 69% of the raw coal cleaned in 1958 and about 55% in 1967. The ash content of raw coking coal rose from slightly more than 18% in 1958 to almost 21% in 1965, but the preparation plants have held the ash content of cleaned coking coal at about 8%. In contrast, the ash content of cleaned non-coking coal was more than 15% in 1965.

There are two types of mechanized coal cleaning plants in the U.S.S.R. One type is located near and operated by the coal mines and the other type is operated by the coke-chemical industry. The latter type plants process only raw coking coal while the mine cleaning plants process both coking and non-coking coal. In 1967, coke-chemical works processed about 40 million tons of raw coking coal and the mine plants processed about 196 million tons of raw coal—including 91 million tons of coking coal and 105 million tons of non-coking coal. In addition to the 196 million tons put through preparation plants at the mines in 1967, 51.6 million tons were processed in mechanized screening plants at the mine. Moreover, in 1965 about 40,000 men and women were employed in the coal industry sorting impurities from coal by hand. Figure 44 summarizes coal preparation in the U.S.S.R.

The technology of coal preparation in the U.S.S.R. has lagged behind that of the Free World. In 1965 about 65% of the raw coal processed was cleaned by wet washing methods and the remainder by pneumatic methods. Heavy media separation, widely employed in the West, was only being introduced in the U.S.S.R. with the help of a French contractor. Although this process could reduce preparation costs slightly, it may not be very successful in handling the high proportion of fines in the Soviet coals to be cleaned. The large proportion of fines, as much as 50% to 70% in some instances, is very difficult to cope with in any method of coal preparation. Another problem is the high sulfur content of coking coal from the Donets, which accounts for about 60% of the coking coal produced. From 1958 to 1965, the sulfur content of cleaned Donets coking coal has remained constant at about 2.2%. As a consequence, it still is necessary to blend Donets coal with low-sulfur coals from the Karaganda and Kuznetsk basins to bring down the average sulfur content of coking charges.

e. FOREIGN TRADE 25X1

(1) *Exports* — In 1957 the U.S.S.R. became a net exporter of coal and has remained so. Total exports of coal increased from about 10 million tons in 1958 to a peak of about 23.6 million tons in 1964 and then dropped to 22.3 million tons in 1967. Throughout the period 1958-67 approximately two tons went to other Communist countries for every ton sent to the Free World. Figure 45 shows the export of Soviet coal by destination for 1958-67.

In 1967, almost one seventh of the coal exported was anthracite, most of which went to western Europe. Soviet anthracite has been a traditional household fuel in France, which took about 1.4 million tons of the 3 million tons of anthracite exported in 1967. Relatively minor amounts of anthracite are shipped to the other Communist countries. Japan was the biggest importer of Soviet coking coal in 1967, taking about 2.3 million

tons, and Austria, Italy, and the U.A.R. also imported substantial amounts. The U.S.S.R. also supplies special coking coals in varying amounts to the other European Communist countries with the exception of Czechoslovakia. Some of these countries are themselves significant producers of coal but lack high quality coking coal. Soviet fuel coal imported by Czechoslovakia frees more valuable Czechoslovak coking coal for export to neighboring countries.

(2) *Imports* — In the immediate postwar period considerable amounts of Polish coal were imported by the U.S.S.R. as a replacement for the lost production of the war-ravaged Donets mines. As the Donets mines were rehabilitated, the need for Polish coal declined. The U.S.S.R. continued to contract for Polish coal, but the bulk of the coal was actually shipped to East Germany and credited to the U.S.S.R. as a Soviet export. This trade has persisted to the present and although minor amounts of the Polish coal is shipped to and used by the Soviet Union, much of the ostensible imports of Polish coal go directly to East Germany.

Hungary supplies about 50,000 to 75,000 tons per year of brown coal and brown coal briquettes to Soviet consumers in areas adjacent to the two countries' common boundary. This traffic is a matter of convenience as the Hungarian suppliers probably are closer to the Soviet users than are producing mines in the U.S.S.R.

Communist China also exported coal to the U.S.S.R. in the past. From 1958 to 1965 about 200,000 tons of Chinese coal per year went to the far eastern parts of the U.S.S.R. where it was used mainly for railroad fuel. The Chinese coal was of better quality than that available from local Soviet sources. In 1966, however, this traffic ceased due to deterioration in relations between Communist China and the U.S.S.R., and it has not been resumed to date. Statistics on Soviet imports of coal for selected years from 1958 to 1967 are shown in Figure 46.

f. Transportation and distribution — As hard coals are mined in only a few widely separated centers in the U.S.S.R., the long-distance transport of coal is unavoidable. Although the economic limits for the transport of coal are considered to be in the range of 1,000 to 2,000 kilometers for hard coal and 200 to 500 kilometers for brown coal, actual distances are greater in many instances. The average shipping distances and the exceptional maximum shipping distances for hard coal from the various basins in the early 1960's are tabulated as follows:

Coal basin	Average shipping distance, kilometers	Maximum shipping distance, kilometers
Donets	510-520	800-1,500
Pechora	1,800-1,900	2,300
Kuznetsk	1,550	2,500-3,500
Karaganda	1,250-1,300	2,500

Coal and coke account for a significant share of the railroad freight traffic in the U.S.S.R. About 30% of the total freight originated and 27% of the total ton-kilometers generated by the railroads in 1958 were devoted to transporting coal and coke. Corresponding figures for 1967 were about 23% and 19%, respectively. Detailed statistics for the movement of coal and coke by rail are shown in the following tabulation:

	Millions of tons originated	Billions of ton-kilometers	Average length of haul, kilometers
1958	478.8	348.9	729
1960	492.5	333.8	678
1962	514.1	347.5	676
1963	544.2	378.6	696
1964	565.9	375.9	664
1965	583.0	396.9	681
1966	583.3	394.5	676
1967	600.9	403.2	671

In 1967, in addition to the 601 million tons of coal and coke transported by the railroad system, 16.3 million tons of coal were shipped by river transport and 8.2 million tons by coastal shipping. Truck shipments are relatively insignificant in terms of ton-kilometers because of the very short distances involved, although more than 86 million tons of coal were shipped by common carrier motor transport in 1965.

To reduce the burden on the railroads and to save transportation costs, the U.S.S.R. has endeavored to develop the use of local fuels, including low-quality coals. Each ton of these so-called local coals, nevertheless, moves an average distance of about 310 kilometers. Some low grade coals move much longer distances, particularly in Eastern Siberia and the Far East. In some instances brown coal is shipped as much as 1,700 kilometers on a regular basis in the Far East.

Although national policy has called for the elimination of costly long hauls of coal, the average length of haul for coal and coke by rail has not changed appreciably in recent years. In 1967, the average length of haul was still 671 kilometers, about the same as during 1960-62.

g. Consumption — Consumption of coal in the U.S.S.R. has increased from 490 million tons in 1958 to 570 million tons in 1967, an increase of about 16%. Figure 6 gives the estimated consumption of coal for 1958, 1960, 1963, 1965 and 1967. The most important users of coal in the U.S.S.R. are the thermal electric power and heat stations, which used about 54% of all coal consumed in 1967. The use of coal by these plants in 1967 had increased by about 79% compared to their consumption in 1958 and their consumption is expected to continue to increase. The communal and household sector showed the greatest percentage increase from 1958 to 1965, a gain of about 77%, but this use declined in 1967 as more natural gas was made available for comfort heating. The use of coal for making coke,

FIGURE 6. ESTIMATED CONSUMPTION OF COAL

25X1

(*Millions of tons*)

	1958	1960	1963	1965	1967
Thermal electric power and heat stations	173.2	217.3	258.5	286.0	310.0
Industry and construction	80.0	58.0	44.5	46.0	40.0
Ferrous metallurgy	83.6	92.6	103.0	108.0	113.9
Of which, coke plants	72.5	81.5	92.9	97.4	102.9
Railroads	95.2	73.1	50.0	35.0	23.6
Of which, locomotive use	79.3	58.4	37.0	22.3	11.0
Communal and household	48.0	50.0	81.0	83.0	75.0
Agriculture	5.0	5.0	5.0	5.0	5.0
Other	5.0	4.0	3.0	2.0	2.5
Total	490.0	500.0	545.0	565.0	570.0

a basic raw material in the iron and steel industry, has increased at a more moderate rate. Approximately 103 million tons of coal were used to make coke in 1967, or almost 34% more than in 1958. Requirements for coal by agriculture are believed to have been fairly stable throughout 1958-65.

Reflecting the increasingly greater dieselization and electrification of the rail system, the total use of coal by the railroads dropped more than 75%—from about 95 million tons in 1958 to less than 24 million tons in 1967. It is likely that this trend will persist until use of coal by railroads is relatively insignificant. Use of coal by industry and construction also has decreased considerably. Such use was about 50% less in 1967 than in 1958.

h. STOCKS — The U.S.S.R. attaches great importance to the maintenance of adequate stocks of raw materials, including coal, so that shortages will not impede the steady development of the economy. Stockpiling policy is influenced generally by three special factors: the great distance between producers and consumers, the nature of the climate, and the fact that additional stocks must be available to consumers attempting to overfulfill their planned production. The exact level of stocks is determined separately for each undertaking or group of undertakings, depending on the particular sector of the economy.

Although little is known about Soviet stocks of coal, it is believed that they have been generally below planned levels and local shortages have been reported from time to time in recent years. The change-over from coal to natural gas by large consumers has not always proceeded as planned, and stocks of coal have varied considerably in recent years. For example, in the years 1958 through 1962 a total of 22.3 million tons of unneeded anthracite fines accumulated at Donets mines as electric power stations converted from coal to natural gas. As a consequence, production of coal was deemphasized and coal requirements and stocks were underestimated. In 1963, the situation changed abruptly and during 1963-64 it was necessary to use more than 18 million tons of the 22 million tons of fines stored at the mines to supplement output. In 1965, the supply situation was still acute and it was necessary to use 500,000 tons of imported Polish coal to supply the domestic market in the Ukraine. In 1966, however, the supply situation eased as there was less demand for coal due to the greater availability of natural gas. Since 1966 there have been no known supply deficiencies other than the routine complaints of lags in shipments scheduled by rail.

Stocks usually are accumulated during the summer when fuel requirements are at a minimum. Coal consumers who are distant from their sources of supply generally maintain larger stocks than those closer to the mines. With the exception of anthracite and low-volatile bituminous coals, Soviet coals do not store satisfactorily for long periods of time. Brown coal, as well as bituminous coal with a high moisture content, weathers and disintegrates rapidly and may ignite spontaneously.

i. EQUIPMENT AND TECHNOLOGY — Although the U.S.S.R. has some thick coal deposits that are exploited by strip mining, about 75% of the total output is still produced by underground mines. Practically all of the underground mines are shaft mines because the coal beds are usually too deep and geological conditions are seldom favorable for developing drift or slope mines. Numerous problems, such as the varying thickness of seams, steep and variable pitching seams, faults, unstable roof and floor conditions, excessive water and gas, and susceptibility of many coals to spontaneous combustion, are encountered in the underground mines. Many of these conditions become more severe as mining depths increase. Moreover, new hazards arise with greater depths. In the Donbas, for example, special precautions have become necessary to guard against the greater frequency of rock bursts encountered in the development of new mines and the extension of old mines to greater depths. In the Donbas, rock bursts increased in number from 14 in 1962 to 189 in 1966. They occur mainly in sandstone formations and at depths of 900 to 1,250 meters. The average amount of rock freed per burst amounted to 430 tons in 1966. Rock bursts also occur in the Pechora basin but no data are available on their frequency or size.

The Soviet coal industry has passed through several stages in technological development since World War

II. In the immediate postwar period the emphasis was on the reconstruction of the mines wrecked during the war. A major objective in the 1950's was the mechanization of the different stages—extraction, loading, and transporting—in the conventional mining cycle. Mechanized coal mining and loading machines ("combines") were developed and gradually supplanted the classic undercutting and loading machines. With one exception—mechanized loading—the Soviet coal industry had mechanized most of its mining operations so that by 1958 they compared favorably with the operations of other leading European coal producers.

Mechanized loading of coal at the working face has continued to lag in the U.S.S.R., however, and persists as a formidable obstacle to increasing labor productivity. In 1966, about 92% of the U.S. underground production was mechanically loaded, but the corresponding Soviet index was only 71%. The extent of mechanized loading in underground coal mines in the U.S.S.R. is shown as follows, in percent of total underground output mechanically loaded for selected years:

1958	40.0
1960	48.8
1962	56.4
1966	71.3
1967	74.0

Much of the failure in mechanized loading stems from the difficult conditions encountered in mining thin, steeply pitching seams, particularly in the Donbas. About 10% of the national underground output and about 45% of the output in the Donbas is mined from steeply pitching coal seams of thin to medium thickness (0.5 meter to 1.5 meters). The development of mechanized equipment to cope with these conditions was time-consuming and not too successful prior to 1965. Since that time more promising models have been developed.

During 1958-63 the technology of the Soviet coal industry fell behind that of western Europe in four important sectors: 1) mechanization of loading, 2) development and application of combines for mining thin, pitching seams, 3) mechanized roof supports, and 4) concentration of operations at fewer but more productive working faces. It is likely that this slow-down in technological growth was due to the lower priority accorded to coal mining in the allocation of investments in the early 1960's.

Beginning in 1964, investments were increased and an ambitious program of reequipment and improvement of the coal industry was undertaken. Major trends in this latest phase include the development and manufacture of modern equipment (both underground and strip mining) the modernization of older mines, and the construction of new large-sized mines. These efforts have produced varied results—good gains in making modern underground mining machinery but poor performance in the commissioning of new mines on schedule. In the Donbas the new big underground mines have required as much as 9 to 17 years for completion instead of the prior normal average of 6 to 8 years. The greater frequency of rock bursts and the high temperatures encountered in the new and deeper mines have increased the cost of excavation in development workings from 2 to 2.5 times that of the original estimate. The U.S.S.R. still lags in the manufacture of specialized giant-sized strip mining equipment on which the success of the planned big strip mines in the eastern regions is predicated.

The underground mines are being supplied with greater amounts of machinery and equipment, which although not of top quality by Western standards, still is better than that used previously. Complaints mainly concern the poor performance of critical components such as hydraulic valves, electric switches and controls, springs, the low quality of repair work at mine shops, and the lack of spare parts. Typical of the lag in technology is the fact that the U.S.S.R. did not begin to replace oil in hydraulic roof supports with a fire-resistant water-oil emulsion until 1967. A creditable achievement, however, has been the design and production of 2 narrow-web coal combines for working steeply pitching seams of thin to medium thickness. These two specialized machines are known as the "Temp/Ukr-1K" and the "Komsomolets." Unlike the practice in other countries, where this type of coal seam is usually worked by ploughs or combines on a longwall parallel to the strike of the bed, the Soviet machines operate on a longwall running up the dip of the bed. Another apparently successful machine is the new PK-8 heading machine, similar to one type of American continuous miner. The Soviet model—also sometimes called a development combine or tunnelling machine—is used for driving development entries and workings, a stage in Soviet coal mining that has been notorious for its slowness and inhibiting effect on production. Figure 7 shows the new PK-8 heading machine. Figure 8 shows the coal-cutting heads and Figure 9 shows the self-advancing support system of one of the latest Soviet longwall complex mechanized units.

The inventory and utilization of the more important pieces of underground equipment in the possession of the Ministry of the Coal Industry, as of 1 January 1968, is shown in Figure 10. Compared to previous years, some units such as locomotives, loaders, and conveyors are not as numerous, indicating the replacement of old obsolete equipment with fewer but newer and more powerful units of greater individual capacity.

The U.S.S.R. is considerably behind the United States in strip mining equipment. Most of the power shovels are small with bucket capacities of 6 to 8 cubic meters (about 8 to 10 cubic yards) and a few large ones with 35 cubic meter (46 cubic yard) buckets. The largest American dragline, scheduled for initial operation in the fall of 1968, will have a 220 cubic yard (168 cubic meter) bucket. The biggest Soviet dragline planned—still in the design stage—will

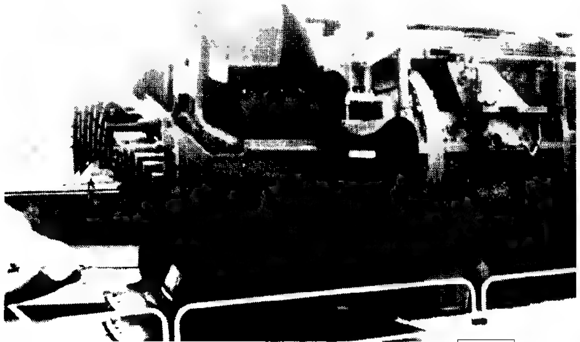


FIGURE 7. SOVIET PK-8 HEADING MACHINE

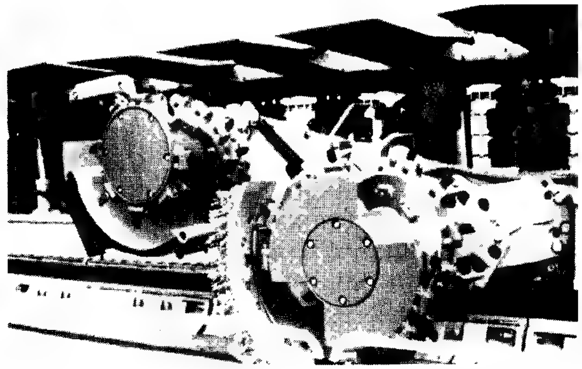


FIGURE 8. CUTTER HEADS OF SOVIET SELF-ADVANCING LONGWALL MINING UNIT

25X1

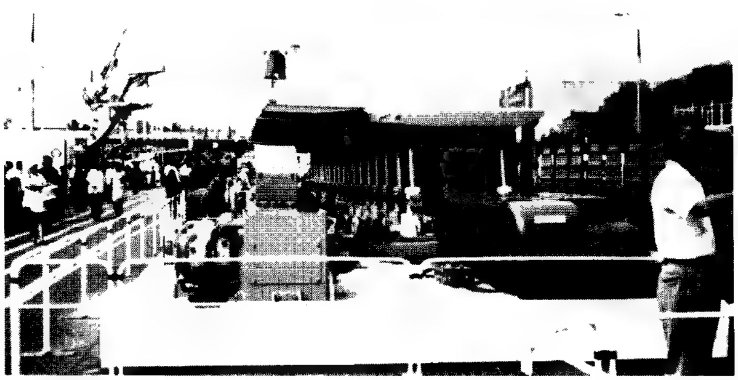


FIGURE 9. SUPPORT SYSTEM OF SOVIET SELF ADVANCING LONGWALL MINING UNIT

25X1

have a bucket of only 80 cubic meters, less than half the capacity of the American machine.

j. MINING METHODS — About three-fourths of the total Soviet output of coal comes from underground mines and the remainder is strip mined. The most widely used method of underground mining of coal in the U.S.S.R. is the longwall method, which involves complete removal of coal from long working faces. There are two variations of the longwall method: advancing longwall and retreating longwall. In the advancing longwall method mining progresses away from the shaft. Development costs are low and mine production capacity is attained in short order. With time, however, the maintenance and repair of haulageways and entries from the shaft through worked-out areas to the producing faces become more and more costly and may become prohibitive. In the retreating longwall method the haulageways, entries, and air courses are first extended to the boundaries of the mine before extraction starts. Only then does production start as the longwall faces are worked toward (retreating to) the shaft. As extraction proceeds toward the shaft the haulageways and entries in the caved, worked-out areas are progressively abandoned with a consequent major reduction in the cost of maintaining and repairing them. The disadvantages of the retreating longwall, relative to the advancing longwall method, are the greater investment required and the much longer time elapsed before the mine reaches the production stage. The U.S.S.R. gradually is changing from advancing to retreating longwall mining and this change undoubtedly has increased the average time required to get new mines into production.

Steeply pitching, thick, coal seams are generally mined by a method called diagonal slicing. The seam is removed in benches, working from top to bottom of the coal, by working faces advancing up the pitch. Somewhat similar is the shield method, where massive steel supports protect the miners as they work slices from top to bottom of the coal seam. A relatively minor amount of coal is also mined by the classic room and pillar method, which requires thick horizontal seams and favorable geologic conditions. Another method is so-called "hydraulic" mining, in which the coal seam is drilled and blasted or cut up by mechanized cutting machines and then moved along the floor of the workings by powerful water jets. Some of this coal is also transported vertically through pipelines by pumping.

FIGURE 10. INVENTORY AND UTILIZATION OF UNDERGROUND MINING EQUIPMENT, MINISTRY OF THE COAL INDUSTRY, JANUARY 1, 1968

(Units and percent of total units)

TYPE OF EQUIPMENT	INVENTORY	PERCENT OF UTILIZATION
Mobile mechanized roof support systems	568	*80.3*
Coal combines	4,044	*69.9*
Of which, narrow web	1,775	*66.8*
Coal ploughs	85	*68.2*
Heading machines	602	*75.1*
Loaders*	5,157	*75.8*
Scraper conveyors	39,626	*85.8*
Belt conveyors	12,978	*91.1*
Electric mine locomotives	14,314	*87.1*
Mine cars	694,281	*93.3*

*Estimated at 30% coal loaders and 70% rock loaders.

Production of coal by hydraulic mining was 3 million tons in 1962 and 5.6 million tons in 1967.

The different mining methods and the percent of underground-mined coal produced in 1966 by each method follows:

MINING METHOD	PERCENT OF UNDERGROUND OUTPUT
Retreating longwall	*50.0*
Advancing longwall	*35.0*
Diagonal slicing	*8.2*
Shield system	*3.2*
Room and pillar	*1.7*
Other	*1.9*
Total	*100.0*

In 1966, about 146 million tons of coal were produced from strip mines in the U.S.S.R. Of this total, 143 million tons were produced from mines under the control of the Ministry of the Coal Industry. Approximately 59 million tons of hard coal were obtained from 28 strip pits and about 84 million tons of brown coal from 36 strip pits. Included in the brown coal output were 10 million tons of brown coal from 6 strip mines located in the Ukrainian S.S.S.R. The remaining 58 strip mines were located as follows: 2 in the Moscow coal basin, 9 in the Urals, 43 in the Siberian and Far Eastern Regions, and 4 others at locations not revealed.

About 3.8 cubic meters of overburden were removed per ton of coal produced in 1967. Comparable data for 1950 were 2.9 cubic meters of overburden per ton of coal. Methods of overburden disposal in 1965 follow:

METHOD OF OVERBURDEN DISPOSAL	PERCENT OF TOTAL
Direct dumping by excavator	*31.0*
Bridge conveyor	*9.1*
Railroad dump cars	*41.2*
Dump trucks	*13.1*
Other (including hydraulic removal)	*5.6*
Total	*100.0*

k. EMPLOYMENT — The coal mining industry is the largest employer among the fuels industries. It employed about 1.2 million people in 1966, mor 25X1 1 million of them wage workers, the category on which calculations of labor productivity customarily are based. Total employment and the number of wage workers in the Soviet coal industry in selected years follows in thousands:

	TOTAL EMPLOYMENT	WAGE WORKERS
1958	1,256	1,071
1959	*na*	1,074
1960	1,196	1,031
1961	*na*	1,005
1964	1,081	988
1965	1,200	1,016
1966	1,202	1,011

na Data not available.

Data on labor productivity, comparable to that of other countries, are not available for the U.S.S.R. The information available is generally compiled on a different basis and is frequently obscure and limited in application. An occasional reference to labor productivity in terms better known in the west may be misleading because of qualifications. In 1960, for example, total productivity for all labor engaged in underground mining was reported as 1.6 tons per man-shift while that of underground workers was 2.2 tons per man-shift. However, these figures excluded labor engaged both in the driving and the repair and maintenance of shafts, entries, haulageways and aircourses.

Instead of the customary index of physical output per man-shift or man-day, Soviet productivity is usually reported in terms of output per worker per month or year. Based on an index of tons of coal produced per month, average labor productivity in Soviet underground mines in 1967 was about 24% greater than in 1958, ignoring decreases in length of the working day. Corresponding approximate increases for strip mines and for all coal mines combined were 14% and 30%, respectively. Figure 11 shows Soviet labor productivity in coal mining for selected years. Compared to the gain in average labor productivity of the bituminous coal industry in the United States—about 55% from 1958 to 1965—the Soviet national average of about 30% is not impressive. One factor contributing to the Soviet lag is the high percentage of wage workers engaged in surface work at underground mines, 22% in 1966-67.

The coal miner is the highest paid industrial worker in the U.S.S.R. In the second half of 1958, the entire coal industry shifted to a six-hour day for most underground workers and to a seven-hour day for all other workers. The six hours underground is actual working time and excludes travel time to and from the working place. There is, however, a "break" of 20 to 25 minutes underground for lunch or refreshment. By 1970, it is planned to reduce underground work to a

FIGURE 11. AVERAGE LABOR PRODUCTIVITY IN COAL MINES
(*Tons per man per month*)

TYPE OF MINE	1958	1960	1962	1963	*1966	*1967
Underground mines	33.2	35.7	37.2	38.4	40.5	41.3
Strip mines	226.7	234.4	235.9	246.8	253.2	258.0
All mines	40.1	43.2	45.6	47.5	51.1	52.2

*Ministry of the Coal Industry only; accounts for about 99% of national output.

30-hour week. The minimum daily pay of an underground worker in 1967 was 3 rubles 20 kopecks while the operator of a combine earned 9 rubles a day (about US$3.55 and US$10, respectively, at the official rate of exchange). In 1967, the average monthly earnings of all industrial workers was 109 rubles; that of the average coal miner, almost double that of industrial workers.

l. INVESTMENT — Annual investment in the coal industry of the U.S.S.R. in the postwar period increased steadily to a peak of 1.2 billion rubles in 1957. In 1958, the upward trend was reversed and annual investment declined dropping to 904 million rubles in 1961. Thereafter began a second rising trend that has continued through 1967. The lower priority accorded the coal industry in the allocation of investment in the period 1958-64 is illustrated by comparison with other more favored sectors of industry. Investment in industry as a whole in 1964 was 67% more than in 1958. The comparable increase in investment in the oil and gas industry was 87%, in the chemicals industry 328%, and in machine building 106%. In contrast, annual investment in the coal industry increased by only 2.5%.

Capital investment has generally been below planned levels. The Seven Year Plan (1959-65) provided for a total investment in the coal industry of 7.5 to 7.8 billion rubles, but actual investment only amounted to about 7.2 billion rubles. The Five Year Plan for 1966-70 calls for 7.25 billion rubles of investment or an average of about 1.45 billion rubles per year. Actual investment for the first two years of the plan period, 1966 and 1967, has probably not exceeded 1.3 billion rubles per year. Details on yearly investment in the coal industry are shown in Figure 12.

There has been a change in the allocation of investment in recent years. Less capital is allotted for construction of new mines while more investment has been put into reconstruction and mechanization of old mines and the construction of more preparation plants. The new mines underway and those planned for future construction are more costly as they are bigger and require more time to develop. In 1966 the annual average output of a coal mine was 478,000 tons. The average annual planned capacity for mines scheduled for completion during 1966-70 is 750,000 tons, while those to be put in operation during 1971-75 will have an average capacity of about 1.5 million

FIGURE 12. INVESTMENT IN THE COAL INDUSTRY IN THE POSTWAR PERIOD
(*Millions of constant rubles*)

25X1

YEAR	ANNUAL INVESTMENT OR YEARLY AVERAGE
1945-50	500
1950-55	700
1956-58	1,070
1959-65	1,030
1966-70 plan	1,450
1958	1,092
1960	987
1961	904
1962	937
1963	987
1964	1,119
1965	1,207
1966	1,250
1967	1,281

tons per year. The cost of new mining equipment also has increased markedly, an important cost factor in modernizing old mines. For example, the cost of equipping a 100-meter longwall face with an old style combine, movable conveyor, and individual supports was about 35,000 rubles. To equip the same working place with the latest KM–87 complex mechanized unit system costs approximately 300,000 rubles, or more than 8 times the cost of the old equipment. On a national basis, the average capital investment necessary per ton of increased production rose from 23.8 rubles in 1956-60 to 47.33 rubles in 1961-65. According to preliminary estimates made in 1967, this investment will increase further to about 51.25 rubles per ton during 1966-70.

m. COSTS OF COAL — Except for some thick seams of coal in the eastern regions, which can be strip mined, Soviet coals are relatively expensive to mine. The high cost of production at underground mines reflects to a large extent difficult mining conditions. In the last 10 years the costs of mining coal have risen constantly, although the true situation has not been readily apparent in official statistics prior to 1967. In 1967, published average cost figures for the Ministry of the Coal Industry show an increase of about 41% over those in 1966. This abrupt jump is largely attributable to the general reform of wholesale prices that took effect in mid-1967. Most of the increased cost is believed due to the greater cost of materials used in the coal industry and to the inclusion of interest charges for capital invested. Average

costs for production of coal in the U.S.S.R. for various years are shown in the following tabulation:

	Rubles per ton
1958	7.68
1960	8.02
1966	8.69
1967 *	12.24

* Ministry of Coal Industry only, January-September 1967. Includes increased costs of materials and interest charges for capital invested.

Underground mining costs are considerably higher than strip mining costs and mining costs are generally higher in the main western basins. As of 1966, and prior to the new economic reforms, the average underground mining cost was about 11 rubles per ton and that of strip mining about 2.2 rubles per ton. In terms of calorific value, coal is generally cheaper to produce than peat and oil shale, but is much more expensive than either natural gas or crude oil.

Wages and salaries comprised almost two-thirds of the production cost of coal in 1955 and more than 55% in 1965, as shown below, in percent of total cost:

	1955	1965
Wages and salaries*	64.1	55.8
Materials**	17.6	16.1
Fuel	0.7	0.9
Electric power	3.2	3.3
Amortization	6.3	15.0
Other***	8.1	8.9

* Includes social insurance deductions.

** Includes timber, explosives, spare parts, etc.

*** Includes services of repair shops and laboratories, training of cadres, etc.

n. Prices — In the past, coal prices generally were established deliberately below the cost of production and the coal industry had to be heavily subsidized. From time to time prices have been increased, but in two instances, in 1952 and in 1955, prices were reduced slightly due to lower production costs. Wage increases granted coal miners in 1956 and 1958 and the increase in amortization norms in 1961 increased production costs substantially. The annual loss—and the necessary subsidy—increased year by year. From 1958 to 1966 the annual loss more than doubled—from 721 million rubles in 1958 to more than 1.7 billion rubles in 1966. In 1967 there was a marked reduction in the annual deficit as a result of the increased prices introduced in July of that year. Annual losses for selected years, in millions of rubles, follows:

1958	721
1960	812
1962	820
1964	1,378
1965	1,582
1966	1,718
1967	531

In 1966 the loss was reported to represent 18% of capital or 25% of the cost of production. As part of a general economic reform in the U.S.S.R., commencing in 1966 the coal industry began converting to a new system of planning and economic incentives; all enterprises were supposed to be working under the new arrangements by the end of 1968. As part of a general price reform that took effect on 1 July 1967, a new price schedule for coal was put into effect. As a result the coal industry has now become profitable. According to preliminary data it earned 8% to 9% on fixed and working capital in the first few months after the price changes took place. Nevertheless, about 30% to 40% of the coal mines still operate at a loss. Most of these mines, however, are small, high cost producers that will be phased out in the near future.

The new price schedule of 1 July 1967 provided for an average increase of 78% in price, including an increase of 93% for coking coal and 70% for general purpose fuel coal. Retail prices for household users were not increased, however. The new prices of July 1967 were based on the average cost of production for the individual coal basin, deposit, or mining district, with allowance for the increased costs of materials and charges for capital. Two examples of the new average wholesale prices have been published thus far: 17.5 rubles per ton for Donets coal and 10.3 rubles per ton for Kuznetsk coal. Corresponding prices prevailing before the change were 9.4 rubles per ton for Donets coal and 6.3 rubles for Kuznetsk coal.

3. Coke

25X1

a. General — The term "coke" in the U.S.S.R. generally refers to high-temperature coke (produced at 900 degrees Centigrade and above), most of which is used in the blast furnaces of the iron and steel industry. The coking industry is under the control of the Ministry of the Iron and Steel Industry. Soviet coke plants are usually located near their sources of coking coal, although in the Urals coal for making coke is brought in from the distant Karaganda and Kuznetsk basins. Practically all of the Soviet coke is made in modern byproduct, slot-type ovens. Coke-oven gas and other byproducts are important sources of such chemicals as benzol, phenol, toluol, cresol, anthracene, and xylol.

b. High-temperature coke

(1) *Production* — The U.S.S.R. has ranked first in the world in coke production since 1960 when it surpassed the United States for the first time. Total production for the years 1958 and 1960-68 is shown as follows, in millions of tons (moisture content 6%):

1958	50.89
1960	56.23
1961	58.60
1962	60.93
1963	63.87
1964	66.28
1965	67.46
1966	68.49
1967	69.90
1968	71.50

Most of the coke is produced at plants in the western regions, particularly in the Ukraine. The original goal for 1965 called for production to reach 76 million to 80.6 million tons of coke, but this goal subsequently was revised downward to about 74 million tons. Actual output in 1965 was about 67.5 million tons. Nonfulfillment of the plan was not so serious as it might appear because the amount of coke required to smelt one ton of pig iron was reduced during 1959-65. Current plans, as of 1968, indicate an output of about 78 million tons for 1970.

(2) *Quality* — Despite tremendous resources of coal, the Soviet coke industry is handicapped by a relative scarcity of high-quality coking coals. Careful blending of many different types, including weakly caking and non-caking coals is necessary to augment supplies of better quality coals. Furthermore, there has been a gradual deterioration in the quality of raw coking coal as mined. This trend has been countered with more intensive cleaning processes and the quality of the coal charged to the coke ovens has remained fairly constant. A third handicap is the high inherent ash and sulfur content of the Donets coking coals that comprised about 59% of the total coking coal mined during 1958-65.

In 1965, about 69% of the coking coal cleaned was processed at plants belonging to the coal industry and about 31% was prepared at cleaning plants of the coke industry. Average ash content (dry basis) of all raw coal was about 21% while the cleaned coal had an average content of 8% ash. The high sulfur content of Donets coals was conspicuous with an average of 2.4% sulfur before cleaning and about 2.2% after cleaning. Other low-sulfur coals, however, brought the average for all cleaned coal down to about 1.5%.

Coke made from blends of Donets and other coals generally has a high sulfur content, about 1.7% to 1.8%, and about 10% ash. Blends of Kuznetsk and Karaganda coals produce coke with a lower sulfur content, usually about 0.5% to 0.8%, but with a somewhat higher ash content than Donets coke. The average quality of all Soviet coke produced during 1958-65 showed about 10.6% ash and 1.2% to 1.3% sulfur.

Average yield of coke from coal charged is about 77% to 78%. Maximum size of coke is usually less than 100 millimeters. Approximate size composition is 93% lump (+25 millimeters), 4% nut (10 x 25 millimeters), and 3% breeze (−10 millimeters). The general practice is to screen some lump at 40 millimeters and use the +40-millimeter portion in large blast furnaces. Small blast furnaces use the smaller-sized +25-millimeter coke.

(3) *Consumption* — About 91% of all coke consumed in the U.S.S.R. in recent years has been used in ferrous metallurgy. The iron and steel industry proper used about 85% while foundries not located at iron and steel plants accounted for the other 6%. About 63% of the total supply of coke was lump coke used in the blast furnaces of the iron and steel industry to produce pig iron and 22% was used by foundries at iron and steel plants and in the form of breeze for agglomerating iron ore. The remaining users of coke and their estimated share of total consumption were: nonferrous metallurgy, 4%; chemical industry, 2%; and other industry and household use, 3%. The consumption factor for blast furnace production of pig iron for selected years is shown as follows in kilograms of coke per ton of pig iron:

	KILOGRAMS OF COKE
1958	795
1960	724
1962	670
1964	619
1966	616
1967	600

(4) *Foreign trade* — The U.S.S.R. is a net exporter of high-temperature coke. Total exports of Soviet made coke in 1967 amounted to approximately 3.7 million tons, compared to about 2.4 million tons in 1958. Other communist countries, primarily East Germany, Hungary, and Rumania, have been the major recipients of Soviet coke. Official Soviet statistics include the ostensible imports of Polish coke which also are included in exports, as all of this Polish coke is exported to East Germany on the Soviet account. Finland and Denmark have been the major Free World importers of Soviet coke during 1958-67. Soviet exports of coke by country of destination are shown in Figure 47.

c. LOW-TEMPERATURE COKE — Low-temperature coke, or semicoke is produced from bituminous coal, brown coal, and occasionally peat, by heating the raw material, usually in retorts, at temperatures ranging from 450 degrees to 550 degrees Centigrade. In the past the principal products were the tars and oils recovered in the process while the resultant coke (actually a "char") was a byproduct used as a general fuel, as were the gases. The tars and oils were the principal raw materials for the production of synthetic liquid fuels. The present availability of crude oil in the U.S.S.R. probably has eliminated the processing of more costly low-temperature tars and oils and it is doubtful if low-temperature coke is being made in as large amounts as in the past. In 1965, the semicoke plant at Cheremkhovo produced about 120,000 tons.

d. COKE OVEN GAS — Coke oven gas is a byproduct of high-temperature coke production and probably accounts for 85% to 90% of all gas produced from coal in the U.S.S.R. Other sources of gas made from coal are the experimental underground gasification projects, some municipal plants providing town gas, and various industrial plants which generate gas for

their own needs. All of these are of decreasing importance as natural gas is becoming more widely available. It is likely that the production of gas from coal has decreased in recent years. The Moscow Coke and Gas Works, for instance, which formerly made town gas in coke ovens, now concentrates on the production of synthetic ammonia and foundry coke. The output of coke oven gas, however, can be expected to increase concurrently with growth in the production of coke.

The output of coke oven gas has increased from about 19 billion cubic meters in 1958 to 29.5 billion cubic meters in 1967. Approximately 375 to 390 cubic meters of gas are obtained per ton of coke produced. The gas has a calorific value of from 4,000 to 4,400 kilocalories per cubic meter. In 1963, about 31% of the coke oven gas was used for heating coke ovens and boilers at coke plants, 55% was used for metallurgical purposes, about 8% at chemical plants, less than 2% for household use, and about 4% for miscellaneous purposes, including losses.

4. Minor solid fuels

a. General — Peat, oil shale, and fuelwood together comprise a small and declining share of the total primary energy production of the U.S.S.R. Absolute levels of output of peat and oil shale, however, are to increase while the absolute level of fuelwood is expected to decline. In 1967, peat accounted for 2%, oil shale less than 1%, and fuelwood less than 3% of total primary energy production.

Although relatively unimportant nationally, peat, oil shale, and fuelwood are economical for use in localities where great distances separate consumers from sources of cheaper major fuels. In general, these minor fuels are utilized in the region of production, principally by thermal electric power stations and by households.

b. Peat — The U.S.S.R. has the greatest reserves and is the world's leading producer of peat. An estimated 60% of the world's reserves lie in the more than 70 million hectares of peat deposits within the U.S.S.R. Total Soviet reserves have been estimated at 158 billion tons on an air-dried basis, of which 90% are in the R.S.F.S.R. Peat is also produced and used for agricultural and other purposes in the U.S.S.R. but all information in this section is limited to fuel peat.

Peat is extracted seasonally from early May until late September. When the weather is dry, production is high, as in 1963 and 1966. Conversely, exceptionally rainy weather leads to abnormally low production as in 1962 and 1965. As the controlling factor is the weather, output seldom matches planned goals and in 1965 the actual output was far below the planned 71 million tons. Production of fuel peat in the U.S.S.R. by years, in millions of tons, follows:

1958	53.3
1960	53.6
1962	34.7
1963	58.7
1964	59.5
1965	46.0
1966	65.4
1967	60.2

According to the present five year plan peat production should increase to 76 million tons in 1970. Figure 13 provides data on peat production in the U.S.S.R. by regions for selected years.

Peat production in the U.S.S.R. is extensively mechanized and specialized equipment for peat extraction has been developed. Prior to removal of the peat, areas are cleared of timber and brush and drained by a network of drainage ditches. Two methods are used in extracting the peat. In one method, special machines somewhat like a bucket dredge scoop up the peat, mix it to a mud-like consistency, and eject it in ribbon-like masses that are cut into "sod" blocks which are left to dry in the open air. In the second method, the top layer of peat is broken and cut to a depth of 1½ inches and then harrowed and turned over several times to dry. Subsequently the loose "milled" layer is piled in rows and gathered up by other machines. Milled peat is the form most suitable for electric power stations while sod peat is preferred for household use.

The heat content of Soviet peat ranges from about 2,600 to 2,670 kilocalories per kilogram and averages about 2,640 kilocalories per kilogram. In 1967, a breakdown of the total consumption of peat in the R.S.F.S.R., the major producer, showed that approximately 80% was used by electric power stations, 10% was processed into briquettes, and 10% went to communal-household users. In 1965, the national supply of fuel peat was distributed as follows: electric power and steam, 71%; processing, principally briquetting, 12%; and other uses, chiefly domestic, 17%.

c. Oil shale — Soviet production of oil shale has grown slowly but steadily from about 13 million tons in 1958 to 21.6 million tons in 1967. Approximately

Figure 13. PRODUCTION OF FUEL PEAT BY AREA
(*Millions of tons*)

	1958	1960	1962	1963	1966
R.S.F.S.R.	35.8	36.8	20.9	37.9	43.7
Ukrainian S.S.R.	4.5	4.7	4.1	5.1	5.2
Belorussian S.S.R.	8.9	8.3	7.1	11.0	12.4
Latvian S.S.R.	1.6	1.8	1.1	2.2	1.8
Lithuanian S.S.R.	1.9	1.6	1.1	1.9	1.4
Estonian S.S.R.	0.4	0.5	0.4	0.6	0.9
Total, U.S.S.R.	53.3	53.6	34.7	58.7	65.4

Note Figures may not add to totals because of rounding.

three-fourths of the output comes from the Estonian S.S.R. where the richest deposits are located. Total geologically possible reserves of the best quality oil shale in Estonia have been estimated at about 13 billion tons. Other deposits being worked are located in Leningradskaya Oblast' and the Volga region of the R.S.F.S.R.

Of the 16.1 million tons of Estonian oil shale mined in 1967, 4.2 million tons, or about one-fourth, came from strip mines and 11.9 million tons were extracted in underground mines. Both longwall and room and pillar mining are used in the Estonian underground mines, with the room and pillar system mechanized in a manner similar to American coal mining. The use of shuttle cars, conveyors, roof-bolting, and like improvements is reported to have raised labor productivity to 18 to 19 tons per man shift, compared to 7 to 8 tons per manshift for the longwall system. Plans call for more strip mining where possible and for additional conversion to the mechanized room and pillar system. The five year plan set 21.5 million tons as the 1970 goal for the Estonian oil shale industry and 28 million tons for the U.S.S.R. as a whole. Production data by republics for selected years is shown in Figure 14.

Oil shale is used as a raw material to produce gas, oil, and chemical products, and is burned directly as a fuel. The ash residue also is used as a raw material for building materials. Recent trends indicate a growing use of oil shale as a fuel and a decline in its conversion to other products. In 1965, about 59% of the oil shale consumed in the U.S.S.R. was used to generate electric power and steam, 37% was processed to make oils and gases, and 4% went for miscellaneous purposes.

d. FUELWOOD — Fuelwood represents a minor and decreasing share of the soviet fuel balance. However, fuelwood is more important in the national fuel supply than Soviet statistics reveal, because such statistics do not include a tremendous volume of wood that is cut by republic and kolkhoz organizations from their own timber lands and wood that is cut illegally. The amount of fuelwood cut in this fashion is almost as much as that reported officially. Total fuelwood production in 1967 was estimated at 192 million cubic meters, whereas only 96.1 million cubic meters were reported officially. Officially reported fuelwood production for selected years follows, in millions of cubic meters:

1958	124.1
1960	108.0
1962	97.0
1963	102.3
1964	108.4
1965	104.5
1966	101.0
1967	96.1

Of the total fuelwood consumed in 1965, household and communal users accounted for 90%, 8% was used for the generation of electric power and steam, and about 2% was processed into other products. Although fuelwood is of minor importance as an industrial fuel, some industrial sectors which produce cellulose, paper, and chemical products from wood, operate chiefly on wood fuel. This is especially true in the forested northern and northwestern regions of the country. Fuelwood will probably remain an important local fuel for household and communal use by the population of the forested areas of the Urals and Siberia.

5. Fuel briquettes 25X1

Briquettes, manufactured from coal and peat, improve the quality and increase the efficient utilization of low grade fuels. A major gain in briquetting anthracite and bituminous coals is the conversion of fine sizes to lumps which can be more widely used than the original fines. In the case of brown coal or peat, briquetting is an effective method not only of obtaining lumps of uniform size but also of enhancing the heat value by reducing the original high moisture content. Hard coal briquettes are made by mixing tar or pitch with the fines and then pressing the mixture in molds to produce a lump-sized product. Brown coal and peat briquettes are generally made without a binding agent; instead the raw material is dried and then compressed at high pressures to make the briquettes. Although Soviet hard coals as mined contain a high percentage of fines, and despite the fact that about one fourth of the total coal output is high moisture brown coal, the briquetting industry is of minor importance in the U.S.S.R. Consumers of coal are forced to use a great deal of fine sizes and high moisture brown coal with a consequent loss in the efficiency of utilization.

Most of the plants producing briquettes from coal are located in the Ukrainian S.S.R. while the R.S.F.S.R. accounts for most of the peat briquettes. Estimated

FIGURE 14. OIL SHALE PRODUCTION 25X1
(Millions of tons)

	1958	1960	1962	1963	1964	1965	1966	1967
R.S.F.S.R.	4.2	4.9	5.1	5.4	5.5	5.4	5.3	5.5
Estonian S.S.R.	9.0	9.2	11.2	12.9	14.7	15.8	16.1	16.1
Total, U.S.S.R.	13.2	14.1	16.4	18.3	20.2	21.3	21.4	21.6

NOTE: Figures may not add to totals because of rounding.

production of fuel briquettes by type for selected years follows, in millions of tons:

	Hard coal	Brown coal	Peat	Total
1958	0.6	4.2	0.8	5.6
1960	0.9	4.3	0.9	6.1
1962	1.3	4.4	1.0	6.7
1965	*na*	*na*	3.5	10.1
1967	*na*	*na*	3.5	10.3

na Data not available.

Practically all fuel briquettes are used for communal-household heating.

6. Charcoal

In the past charcoal was produced mainly for making pig iron, the charcoal being used like coke in small blast furnaces. The pig iron made with charcoal is of premium quality and despite its high cost continues to be made, chiefly in the Urals. The production of charcoal pig iron has declined, however, from 26,000 tons in 1958 to about 7,000 tons in 1966, with a correspondingly decreasing requirement for charcoal.

Charcoal is also obtained with other wood byproducts in distillation processes employed at wood chemical plants. These plants are located mainly in the western regions of the country. Considerable charcoal is needed in the production of activated and purified carbon and also of carbon bisulfide. Activated carbon has many uses in processing and refining plants and the demand for it has undoubtedly increased. Production plans for charcoal from wood chemical plants called for three times as much output in 1965 as in 1958. Data on actual production of charcoal are not available and it is not known to what extent these plans were fulfilled.

7. Manufactured gas

Although the over-all importance of manufactured gas is declining with the increasingly greater availability of natural gas, the output of some manufactured gases such as coke oven gas and blast furnace gas will continue to grow as they are byproducts derived from other industrial processes. In 1965, about 22% of all gas, both manufactured and natural, produced in the U.S.S.R., in terms of heat value, was manufactured gas. This 22% was comprised of about 8% coke oven gas, 11% blast furnace gas, and 3% gas made from coal and oil shale.

The combined output of town gas made from coal and oil shale probably reached a peak in 1961 when more than 1.9 billion cubic meters were produced. In 1967 output of the same gases was 1.7 billion cubic meters. The decline in output of town gas from coal due to the changeover to natural gas and subsequent closing of municipal gas plants has been offset to some extent by increased production of gas by underground gasification. In 1958, output of this gas was about 624 million cubic meters from six different research sites. The only industrial scale underground gasification project was commissioned in 1962 in Uzbekistan. By 1965, the Uzbekistan project had reached an output of about 1.3 billion cubic meters according to press reports. Gas from underground gasification is very low in heat content, about 800 to 990 kilocalories per cubic meter, and it is likely that the experiments will be stopped in the future.

No data on a continuing comparable basis for the production of manufactured gases are available. Some information for 1963 can be regarded as an indicator of magnitude on a volumetric basis for that year. In 1963, the estimated total output of manufactur25X1, excluding gases derived from the processing and refining of petroleum, amounted to approximately 179 billion cubic meters, consisting of 1.6 billion cubic meters from coal and oil shale, 24.2 billion cubic meters of coke oven gas, and about 153 billion cubic meters of blast furnace gas. Possibly included in the gas made from coal and oil shale were an estimated 700 million cubic meters of gas from the underground gasification of coal.

Among the manufactured gases derived from solid fuels, coke oven gas ranks highest in calorific value. Usual ranges of calorific content for the various gases, where known, follows, in kilocalories per cubic meter:

Coke oven gas	4,000-4,400
Town gas	3,900-4,150
Blast furnace gas	900-1,000
Underground gasification	800-990

The two most important gases—coke oven gas and blast furnace gas—are used almost completely for industrial purposes at the plants where they are produced. Town gas is supplied mainly for household purposes. Little is known about the utilization of gas produced by underground gasification, but 25X1 smaller scale projects it is likely most of the gas was used by the project or flared. At the Uzbekistan project surplus gas is probably used by small industrial plants.

C. Petroleum

1. Introduction 25X1

The U.S.S.R. is the second largest producer of crude oil and natural gas in the world, being surpassed only by the United States. In 1968, Soviet production of crude oil was about 309 million tons, about 15% of total world output. Since 1960 the average annual increase in Soviet output has been about 20 million tons and annual goals have been overfulfilled.

Production in the U.S.S.R. is based on large reserves estimated at the end of 1967 at about 4.7 billion tons, approximately 8% of the world's proved reserves of crude oil. These reserves are adequate to support achievement of the announced goals for production of 350 million tons in 1970 and 460 million tons in 1975. The discovery and development of new reserves of

crude oil, however, has not been keeping pace with the increase in production, and the ratio of reserves to production, which was 20 to 1 in 1958, had fallen to 16 to 1 by 1967.

The U.S.S.R. also ranks second in the world in petroleum refining capacity. At the beginning of 1968 total primary distillation capacity amounted to about 255 million tons, not enough to process all of the crude oil produced domestically. According to the original Seven Year Plan (1959-65), primary distillation capacity was to reach 250-260 million tons in 1965, which would have been adequate to process the 243 million tons of crude oil produced in that year. During the seven-year period, however, refinery construction lagged, particularly construction of the secondary refining facilities necessary for improvement of product quality and for greater flexibility in the product mix. Exports of crude oil increased significantly and refinery construction goals were lowered so that excess primary capacity would not be built. During the present Five Year Plan (1966-70) emphasis is being placed on construction of secondary refining units, and primary distillation capacity probably will increase to about 300 million tons per year by the end of 1970.

The supply of petroleum products in the U.S.S.R. has in general been adequate to satisfy the steadily growing domestic demand. There has been an excess supply of rather low-octane gasoline, although in recent years steps have been taken to improve quality. The supply of diesel fuel, the basic fuel of the Soviet economy, has been tight, partially because 10% to 15% of the diesel fuel produced has been exported to earn foreign exchange. The use of diesel fuel has risen rapidly with the widespread use of diesel equipment in agriculture and transport. Consumption of petroleum products in the U.S.S.R. increased at an average annual rate of about 9% during 1959-65, and it is estimated that during 1966-70 the rate of increase will be about 7% per year.

Pipeline transport of crude oil and petroleum products increased from 9.5% of total ton-kilometers of oil freight in 1955 to about 22% in 1965. In spite of this dramatic increase, plans for pipeline transport during the Seven Year Plan period were not fulfilled. Railroads continue to be the principal carrier of liquid petroleum, having accounted for almost 43% of total ton-kilometers of oil freight in 1965 compared to about 66% in 1955. The network of petroleum pipelines in the U.S.S.R. reached about 33,000 kilometers in 1968. Construction of oil pipelines has failed to meet plans since 1959 as a higher priority has been assigned to the building of the natural gas pipeline system.

The U.S.S.R. has been a net exporter of oil since 1955. Total exports have risen from 8 million tons in that year to about 82 million tons in 1968, an average annual increase of about 20%. In 1968, exports of petroleum were equivalent to 27% of total Soviet production of crude oil. The composition of these exports has shifted over the years; in 1955, crude oil represented only 36% of the total whereas by 1968 this share had risen to almost 70%. About 56% of total Soviet exports of oil during 1966-67 was shipped to Free World countries, primarily to the industrialized West to earn foreign exchange for the purchase of equipment and technology. Of the remaining exports to other Communist countries, about 80% goes to Eastern Europe.

In addition to its huge resources of oil, the U.S.S.R. has between one-third and one-half of the world's potential resources of natural gas. Proved reserves of natural gas at the beginning of 1966 were estimated at 2 trillion cubic meters, about 18% of proved reserves in the world. Production of natural gas in 1968 was about 169 billion cubic meters, equivalent to about 205 million tons of oil. Plans for 1970 and 1975 call for gas production to reach 215 billion and 300-340 billion cubic meters, respectively. Attainment of these goals appears doubtful. Past Soviet goals have not been fulfilled and annual increments in production twice the increase of 12 billion cubic meters recorded in 1968 would be required.

Consumption of natural gas has nearly equalled production. Small quantities have been exported, primarily to Poland and Czechoslovakia, and agreements signed in 1966 and 1967 provide for the first imports of gas from Afghanistan and Iran. In recent months, Austria has agreed to import Soviet natural gas through a proposed extension of the existing 28-inch gas line from the U.S.S.R. to Czechoslovakia.

2. Development of resources and reserves 25X1

a. Geology — The prospective oil and gas areas (sedimentary basins) within the U.S.S.R. cover an estimated 11.1 million square kilometers, or about half of the total land and inland sea area. Approximately 7.4 million square kilometers, or two-thirds of the prospective area is considered favorable for the occurrence of petroleum. It is reported that some evaluation has been made of at least 6.5 million square kilometers of the prospective areas in the U.S.S.R.

The most important geological provinces according to producing potential for crude oil and natural gas are the Baku-Caucasus region, the Ural-Volga platform, the Central Asian republics, the West Siberian lowlands in Tyumen and Tomsk Oblasts, and the Central Yakutsk lowlands in Eastern Siberia.

The Baku-Caucasus region was the primary source of crude oil supply in the U.S.S.R. before World War II, but it has been supplanted by the Urals-Volga area, which now provides about 70% of the total output of crude oil. Depletion of the older oil and gas fields west of the Ural Mountains has led to exploration east of the Urals. Major discoveries of crude oil and natural gas have been recorded in the Central Asian republics and in the West Siberian lowlands. The potential for producing natural gas in the Central Asian region exceeds that for crude oil. Large gas deposits have been located in Uzbekistan, Turkmeni-

stan and western Kazakhstan, but oil production is confined largely to western Turkmenistan and the Mangyshlak Peninsula area of western Kazakhstan. Development of the West Siberian lowlands is expected to result in the establishment of a "Third Baku" which will become a major crude oil and natural gas producing region after 1975. Recent discoveries of natural gas in the Yakutsk lowlands also indicate the presence of vast gas reserves in eastern Siberia. The location of petroleum and gas resources in the U.S.S.R. are shown on Figure 75.

In the postwar period major efforts were directed to exploring for and developing Paleozoic oil deposits. The major share of proved reserves and production of crude oil (1966) is obtained from the Paleozoic. On the other hand, the major occurrences of natural gas have been discovered in Cenozoic and Mesozoic deposits, as illustrated in the following tabulation:

GEOLOGICAL AGE OF DEPOSIT	1966 CRUDE OIL AND NATURAL GAS PRODUCTION		RESERVES	
	Percent			
	Oil	Gas	Oil	Gas
Cenozoic	*27.0*	*53.0*	*13.8*	*41.3*
Mesozoic	*2.9*	*34.0*	*3.2*	*48.4*
Paleozoic	*70.1*	*13.0*	*83.0*	*10.3*
including:				
Permian	*2.6*		*1.5*	
Carboniferous	*19.0*		*18.6*	
Devonian	*48.5*		*62.9*	

b. RESOURCES AND RESERVES — Existing petroleum reserves appear adequate to support a 100% increase in the production of crude oil and perhaps a 200% increase in the output of natural gas by 1980. Recently announced goals for 1980 call for slightly more than a 100% increase in production of crude oil and for more than a 300% increase in production of natural gas, based on 1967 rates of extraction. Achievement of the 1980 goal for production of natural gas is un likely even if the ratio of proved reserves to extraction is lowered drastically.

The preferred ratio of proved reserves to annual production has been at least 20 years (20:1) for both crude oil and natural gas. Since 1961, however, exploration efforts to find new reserves of crude oil and natural gas have failed to maintain the desired 20:1 reserves-to-production ratio. Production is being increased at rates which exceed the annual addition to proved reserves. The reduction in the reserves-to-production ratio during 1962-66 is estimated to be much greater in the case of natural gas than for crude oil. Estimated proved reserves of crude oil and natural gas and the changing ratios of reserves to production for selected years from 1950 to 1966 are shown in Figure 15.

The discovery of large new deposits of oil and gas in Western Siberia and Central Asia during the past decade has improved long term prospects, but exploration and development of new Asiatic deposits is still proceeding. Asiatic reserves are expected to supply an increasing share of future petroleum production. At present, only a small portion of the Asiatic reserves have been provén; the greater portion are classified as probable, being much less thoroughly defined.

FIGURE 15. ESTIMATED PROVED RESERVES AND RESERVES-TO-PRODUCTION RATIOS FOR CRUDE OIL AND NATURAL 25X1

AT YEAR END	ESTIMATED PROVED CRUDE OIL RESERVES	RESERVES-TO-PRODUCTION RATIO	ESTIMATED PROVED NATURAL GAS RESERVES	RESERVES-TO-PRODUCTION RATIO
	Million tons		*Billion cubic meters*	
1950......	750	25:1	85	15:1
1955......	1,400	25:1	389	65:1
1958......	2,300	20:1	1,247	43:1
1960......	3,300	20:1	1,667	36:1
1965......	3,900	16:1	2,091	16:1
1966......	4,225	16:1	2,021	14:1

c. EXPLORATION — Exploration in the Soviet petroleum industry includes the dual tasks of locating and evaluating new reserves of crude oil and natural gas for future development. Exploration activities are organized along two separate but related types of operations—prospecting work and exploratory drilling. Prospecting work includes: preparation of composite geological maps for future drilling sites from surface and subsurface geological studies; structural and core-hole drilling; and geophysical surveys which utilize gravity meter, magnetometer, and seismograph data. Exploratory drilling of mapped structures is necessary to verify the existence of crude oil and natural gas deposits and to delineate and evaluate reservoir potential for future exploitation. Development drilling and production usually begins after exploratory drilling has established the presence of adequate proved reserves.

(1) *Prospecting work* — Mapping of oil and gas prospects in the U.S.S.R. has become more difficult in recent years due to the greater complexity of the geology and the increasing prospecting depths. As depths have increased, structural and core drilling have become less reliable tools for subsurface mapping. Rational development led to exploiting first the larger more obvious structures that were located by shallow drilling. In recent years exploration and development in older producing regions has been restricted to the remaining smaller, deeper, more subtle structures that had been deferred for later exploitation. Obsolescence of Soviet seismograph equipment and technology hinders the location of new sites favorable for exploratory drilling. The lack of modern computerized seismograph technology has been particularly detrimental in locating and defining deep structures. Unscientific methods and poor data that complicate the

mapping of subsurface structures also are cited as major causes of unwarranted drilling and dry holes.

The number of Soviet geophysical survey crews was estimated at about 1,000 in 1965, which included 880 seismograph crews and about 120 magnetometer and gravity meter crews. The number of seismograph parties has increased from 118, or 42% of all the geophysical parties in 1950, to 880, or about 88% of all geophysical crews in 1965. This illustrates the increased reliance placed on seismic methods. In general, present Soviet geophysical equipment lacks precision and proper instrumentation, and the poor quality of seismic cable and geophones limits reception.

Investment in geophysical surveying and evaluation of exploratory wells for determining the producing potential of new crude oil and natural gas reservoirs doubled during 1959 66. Annual investment outlays, in millions of rubles and by region of expenditure, are shown in Figure 48.

(2) *Exploratory drilling* — Exploratory drilling in the U.S.S.R. is primarily concerned with defining and evaluating previously mapped subsurface prospects for crude oil and natural gas exploitation. Exploratory drilling accounted for more than half of all the drilling conducted in the U.S.S.R. during the Seven Year Plan (1959-65), and during 1966-67, as shown as follows, in thousands of meters:

	All drilling	Development drilling	Exploratory drilling
1959	7,148	3,386	3,762
1960	7,715	3,692	4,023
1961	8,363	3,830	4,533
1962	8,873	4,065	4,808
1963	9,148	4,287	4,861
1964	10,003	4,687	5,316
1965	10,719	5,151	5,568
1966	11,251	5,603	5,648
1967	11,707	5,905	5,802
Total	84,927	40,606	44,321

More than 70% of the 32.9 million meters of exploratory drilling conducted in the U.S.S.R. during 1959-65 was located west of the Ural Mountains. A regional distribution of exploratory drilling in 1950, 1955, and 1963 follows, in percent:

Region	1950	1955	1963
West of Urals	*80.3*	*79.1*	*72.2*
Caucasus	*44.8*	*28.8*	*24.5*
Urals-Volga	*27.6*	*44.5*	*41.5*
South	*7.9*	*5.8*	*6.2*
East of Urals	*19.7*	*20.9*	*27.8*
Central Asia	*10.6*	*12.5*	*13.6*
West Siberia and other regions	*6.6*	*5.4*	*11.0*
Far East	*2.5*	*3.0*	*3.2*
Total U.S.S.R.	*100*	*100*	*100*

During 1959-65 about two-thirds of the exploratory drilling, or 22 million meters, were drilled for new crude oil reserves and the remainder for gas. The annual goals for exploratory drilling have not been fulfilled since 1957, and additions to proved oil and gas reserves have not kept pace with rising annual production rates.

The underfulfillment of exploratory drilling quotas results, in part, from a noticeable increase in the average depth of all wells drilled and, in recent years, from a decrease in the rate of penetration, shown as follows:

Exploratory drilling indices	1950	1960	1965
Average depth of well drilled, in meters	1,362	1,928	2,269
Drilling rates in meters/rig/month for exploratory wells	209	401	377

The need to drill deeper in search of new reserves is increasing in all of the older producing regions such as the Ukraine, the Urals-Volga, Baku, and North Caucasus and in the new producing regions of the Central Asian republics. Between 1938 and 1958 in the U.S.S.R. a total of only 58 wells were drilled to depths below 3,000 meters; since 1964, however, 150 to 200 wells have been drilled to this depth each year. By 1966, 12 wells had been drilled below 5,000 meters and as of mid-1968, 2 were drilling below 6,000 meters.

A comparison of deep exploratory drilling costs and of actual drilling time per day between the U.S.S.R. and the U.S. reveals a sharp contrast. Soviet sources estimated the average cost per foot of drilling a 6,300-meter super deep test in the North Caucasus in 1967 to range from $75 to $150. In the U.S. more than 400 similar deep wells were drilled and completed in 1966 at an average cost of $46 per foot. Data on Soviet drilling practices reveal that about 16 hours is spent in raising and lowering drill pipe to replace worn-out bits for each 8 hours of actual drilling time below 2,500-meter depths. In the U.S. this ratio is reversed.

In addition to deep drilling directly aimed at finding new oil and gas deposits, there are three other forms of geological exploratory drilling which include support wells, parametric wells, and regional profile wells, that collectively accounted for 4% to 7% of total exploratory drilling during 1962-66. These forms of general reconnaissance drilling are used to compile preliminary data for seismograph surveys and geological mapping of prime areas for future detailed prospecting and drilling.

It is estimated that during 1959-65 about 175 metric tons of crude oil reserves and about 135,000 cubic meters of natural gas reserves were discovered for each meter drilled. During these years the most significant increase in reserves of oil and gas per meter of exploratory drilling was obtained in Western Siberia where the increase was 3 times greater than the national average. The increase in reserves per meter of exploratory drilling was 2.5 times greater than the national average in the Kazakhstan S.S.R. and double the national average in the Uzbekistan and the Turkmenistan S.S.R.'s. Despite these achievements the results of exploratory drilling were only about

80% as effective during 1959-65 as during the previous 5 year period.

d. Technology and equipment — The U.S.S.R. currently lacks modern exploration technology and equipment, which poses serious problems for future development of the petroleum industry. Obsolescent seismic equipment and technology has hindered exploration efforts. Most of the existing exploration equipment and technology for the petroleum industry was designed and developed for operations in the Baku and Urals Volga regions, where most crude oil deposits were located in rather shallow, uniform reservoirs. More recently, exploration activity has taken place at much greater depths and in areas outside of Baku and the Urals-Volga in desert and permafrost terrain. The new operating environments often impose performance requirements that greatly exceed and differ from those for which existing technology and equipment were designed.

Present Soviet geophysical techniques and equipment for deep prospecting are estimated to lag behind those in the U.S. by about 10 years. The ability to locate and define complex structures at greater depths is essential for the development of accurate subsurface geological maps and reducing the number of dry holes. Deep exploration is both time consuming and costly, and is largely dependent on the quality of available seismograph data. Soviet seismic records obtained from deep structures are frequently of poor quality due to the use of "refraction" techniques rather than the accepted western "reflection" methods and also because low frequency signals are ignored. Utilization of the modern digital recording techniques and computerized processing of seismic data is still in the experimental stage. "Horizontal stacking," a new technique developed in the U.S. in 1963, which combines reflection methods with computerized recording equipment represents one of the most significant achievements for deep exploration in the history of the petroleum industry. Soviet experts are aware of this method but apparently lack the computers and/or the instrumentation to apply it.

Soviet instrumentation lacks the precision of western equipment. Nevertheless, Soviet scientists have made some interesting innovations in regional prospecting and in the use of extremely long seismic shot lines reaching up to 570 miles in length. They have initiated the use of recorded earthquake data in seismic studies for mapping basement strata and structures. Magnetic and gravity methods are being used to select areas for detailed seismic surveys and electrical methods are used to eliminate places not worth detailing by seismograph.

Efforts to conduct exploratory drilling below 2,500 meters are handicapped by use of equipment designed for shallower depths. The turbodrill, which was used for about 85% of all wells drilled in the U.S.S.R. in 1967, is an excellent tool for shallow, slant hole and directional drilling, but hole deviation becomes a problem when drilling deep vertical holes. Excessive drill-pipe wear, separations, and accidents are more likely to occur, and penetration rates are slower. The larger diameters of Soviet drill pipe, bits, and turbodrill-borings also serve to reduce the efficiency, speed, and volume of exploratory drilling as depth increases. More use is being made of rotary drilling in combination with turbodrilling, below 2,000-meter depths. Experimental work is being conducted to develop an electrodrill for deep drilling. Widespread operational use of this tool, however, has been prevented by failure to overcome losses of electric current as the current is transmitted through the drill pipe to the drive mechanism and bit.

Shortages of high pressure blow-out preventers on exploratory drilling rigs has led to many drilling accidents, needless blow-outs, fires, and waste of valuable oil and gas resources. Exploratory drilling in the southern regions of the Soviet Union is especially hazardous without blow-out preventers because high pressure reservoirs are frequently encountered. Exploration and production activities in the North Caucasus were forced to cease temporarily for lack of blow-out preventers in 1966.

3. Drilling

25X1

a. General — Since 1950 drilling for crude oil and natural gas in the U.S.S.R. has emphasized exploratory drilling, whereas development drilling predominated in prewar operations. At the present time exploratory drilling accounts for more than half of all drilling. During 1950-65 the average depth of exploratory wells increased from 1,362 meters to 2,269 meters and that of development wells from 1,148 meters to 1,653 meters. The total volume of drilling rose from about 4.3 million meters in 1950 to about 10.7 million in 1965, an increase of about 150%. Figure 49 shows average depths and penetration rates of exploratory and development drilling in 1950, 1960, and 1965.

Exploratory drilling requires larger expenditure of time and money than does development drilling because of the greater average depth per well and the slower rates of penetration. Penetration rates are slower because of the need to sample and test cores as the wells are drilled. Soviet statistics indicate 502 oil deposits and 231 gas deposits were discovered during 1959-66 by the exploratory drilling of 1,005 oil and 282 gas structures.

The drilling of smaller structures and a larger number of small-yield wells has led to the greater volume of development work. More than half of all the crude oil reserves in the U.S.S.R. are concentrated in 24 large structures and about two-thirds of the natural gas reserves are located in 32 structures. When many of these large deposits were drilled, output was maximized at a minimum of investment input. However, as the older fields have been depleted, smaller deposits

have been exploited at greater unit costs, or large new fields have been developed in remote locations that require large capital investments. Most of the present drilling operations are located in the older producing regions, including Azerbaydzhan, North Caucasus, Ukraine, and Urals-Volga, where it is possible to maintain full utilization of existing facilities for production, transportation, processing, and storage nearer the consuming centers. Data for 1966 on the regional output of oil and gas and on depth of producing deposits in the U.S.S.R. are given in Figure 50.

The expansion of the drilling program has necessitated an increase in the supply of drilling rigs, both from domestic output and from imports. During 1956-65 the total number of drilling rigs available for exploratory and development work more than doubled (811 in 1956 to 1,634 in 1965), with the greatest increase in exploratory rigs. Fewer drilling rigs are required for development drilling because average penetration rates are 2 to 3 times greater than for exploratory tests, and the average depth of development wells is only about three-fourths that of exploratory wells. The total number of drilling rigs in use in the U.S.S.R. in 1950 and 1955-65 is shown in Figure 16.

b. Methods and equipment

(1) *Turbodrill* — Approximately 85% of all the wells in the U.S.S.R. are drilled by the turbodrill method which was perfected during the post-World War II development of the shallow but prolific Urals-Volga crude oil deposits. In turbodrilling only the bit at the lower end of the drill stem rotates. In rotary drilling, the entire drilling column is rotated from the surface. The turbodrill rotates at speeds of up to 600 revolutions per minute, whereas rotary tools turn at rates of less than 150 revolutions per minute. Mud pumped down through the drill pipe under high pressure to the turbodrill supplies the drive mechanism for the turbine which impels the bit. There is little or no torque on the drill column. Soviet turbodrill equipment is generally bulkier and heavier than conventional western rotary equipment and uses noticeably larger diameter drill pipe and bits. The relative advantages of rotary and turbodrilling methods depend on the durability of the downhole equipment, especially drill pipe and bits.

Figure 16. Number of drilling rigs in use

Year	Exploratory rigs	Development rigs	Total
1950	849	286	1,135
1955	611	259	870
1956	565	246	811
1957	597	253	850
1958	674	270	944
1959	748	283	1,031
1960	835	310	1,145
1961	950	331	1,281
1962	1,027	342	1,369
1963	1,101	361	1,462
1964	1,185	367	1,552
1965	1,240	394	1,634

The disadvantages of turbodrilling begin to appear when drilling in soft rock strata and when drilling below 2,500 meter depths. The standard turbodrill commences to lose efficiency at 2,000 meters as penetration rates decrease due to accelerated bit wear. Lower mud pump efficiency below 2,000 meters causes a reduction in the mud flow that lubricates and cools the bit; consequently, accelerated bit wear occurs with increased depth and greater axial loads. Changing the bit is a time consuming operation that necessitates raising and uncoupling the entire drill column to replace the worn out bit. Below 2,500 meters turbodrill bits are replaced about twice as frequently as rotary bits.

Modification of the high speed turbodrill method has become necessary because of the increased amount of deep drilling being undertaken in the U.S.S.R. Low-speed multisectional turbodrills are being specially designed to improve performance in soft rock and below 2,000 meters. A series of high-torque turbodrills having a variable automatic fluid flow to improve operation at low speeds is now being tested. Experiments also have begun with internally retractable turbodrill bits which would eliminate the need for pulling the entire drill column. Reduction of diameters and improved metallurgy in the fabrication of bits and drill pipe can also extend the usefulness of turbodrills to greater depths. Mud pumps with pressure ratings of 200-250 atmospheres, compared to the present ratings of 150 atmospheres, would also prove helpful in extending bit life and in improving deep drilling performance. In the U.S., mud pumps rated at 200 and 300 atmospheres are common. Treatment of drilling fluids for removal of abrasive material would also extend the operational life of the turbodrill drive mechanism and lengthen the time between maintenance periods. The production of turbodrills in the U.S.S.R. during 1959-67 was as follows:

1959	4,898	1964	8,280
1960	6,222	1965	8,439
1961	6,752	1966	8,487
1962	7,656	1967	8,322
1963	8,038		

25X1

(2) *Rotary drilling* — Conventional rotary drilling is being used more frequently for deep drilling below 2,000 meters, and in combination with turbodrills for penetrating alternate soft and hard rock formations. The slower bit speeds in rotary drilling increase penetration rates in softer strata and rotary methods also permit use of smaller diameter drill pipe and bits. Greater use of rotary drilling will necessitate improvements in the quality of drill pipe, drill collars, jet bits, and drilling fluids. About 13% of all drilling in the U.S.S.R. probably is by the rotary method.

(3) *Electrodrill* — The U.S.S.R. is developing another type of subsurface motor for drilling called the electrodrill. The electrodrill motor which is located at the lower end of the drill column is powered by electric current transmitted from the surface. The downhole motor develops bit speeds ranging from 400 to 1,000 revolutions per minute. Electric power is transmitted through a conductor line, consisting of separate sections of cable imbedded in the wall of each section of drill pipe. These sections of cable connect as the pipe is screwed together. Air, gas, or conventional drilling mud can be used with the electrodrill as a circulation medium. Loss of electric power along the conductor line constitutes a serious difficulty that prohibits wider use of the electrodrill in deep drilling. It is estimated that only 1% to 2% of all drilling is accomplished with the electrodrill.

(4) *Vibratory drilling* — Vibratory drilling and novel percussion rotary methods are being investigated in the U.S.S.R. The vibratory method employs an impacting of the bit with short time force pulses by means of a subsurface vibrator located above the bit. Certain advantages may result from lower axial loads and lower rotational speeds, but vibrational dampers must be developed to protect the drill column against alternating stresses.

(5) *Bits* — The most serious problem in oil and gas well drilling in the U.S.S.R. is the lack of durability of drill bits. The Soviet petroleum equipment industry manufactures a wide variety of conventional drill bits with varied cutting surfaces, including blade-type bits, jet bits, inserts, tri-cone button and tooth-type roller bits, diamond bits for coring and super deep drilling, and single cone bits. About 900,000 bits of all types were produced in 1965. In general, the quality of the most widely used tri-cone bits needs to be improved by use of better steel and by improved design if bit life is to be extended and drilling penetration rates are to improve.

The use of diamond bits for drilling commenced in 1959, but this technology is still in the development stage. The production of diamond bits increased from 46 in 1961, to 292 in 1965, and is expected to reach 1,600 in 1970. The average penetration per diamond bit increased from 81 meters to 193 meters during 1961-65. In 1966, Soviet drillers claimed an average penetration of 227 meters per bit. Soviet natural diamonds are reported to be more brittle than natural industrial diamonds used in western industry and this leads to shorter bit life. Very little use of synthetic diamonds in bits for petroleum drilling has been reported.

(6) *Blow-out preventers* — Drilling operations in the Soviet Union have, in many cases, proceeded without use of blow-out preventers. Penetration of high-pressure reservoirs containing crude oil and natural gas is extremely dangerous without this emergency equipment and has resulted in blow-outs, well fires, and losses of life, equipment, and valuable hydrocarbon resources. A universal type preventer rated at 320 atmospheres (about 4,800 pounds per square inch) is coming into use. This preventer operates with pipe sizes ranging from 60 to 300 millimeters in diameter, but only 226 were produced in 1965. Soviet efforts to produce and import higher pressure fixtures with 5,000, 10,000 and 15,000 pounds-per-square-inch ratings have failed to keep pace with the demand for these items.

(7) *Tubular goods* — Drill pipe and casing for the oil industry are made of five grades of steel with a maximum yield strength up to 135,000 pounds per square inch. Drill pipe is made in 8 sizes with outside diameters ranging from 60 to 168 millimeters. It is believed that commonly used sizes of oilfield casing and drill pipe are produced at the same plants and are of identical quality and weight except that tool joints are added to the ends to make drill pipe. The general quality of drill pipe is inferior to that in the U.S., but quality has not been a limiting factor because of the absence of torque in turbodrilling. Much of the domestic drill pipe is not suitable, however, for rotary drilling methods at depths of more than 2,000 meters.

Oilfield casing is made in 15 sizes ranging from 114 to 426 millimeters in outside diameter. Much of it is too heavy and inferior in quality by U.S. standards, but the manufacture of higher quality casing has begun.

Light alloy drill pipe for both turbodrilling and conventional rotary drilling is finding wider use and acceptance. The use of aluminum drill pipe with a yield strength of up to 50,000 pounds per square inch has been reported.

(8) *Rigs* — Drilling rigs are produced in various types and sizes in the U.S.S.R. including portable, semi-portable, light, medium, heavy duty, and super deep models, similar to the functional types used in the U.S. Construction differs from that in the U.S. chiefly in the widespread use of tubular steel for derrick and mast construction rather than angle iron. Thus, Soviet rigs tend to be bulkier and heavier and are more difficult to transport to drilling sites. Annual production of all types of drilling rigs increased from 350 units in 1958 to 520 units in 1965. Approximately 70% of the rigs produced are furnished with diesel drives which are most often used for exploratory drilling. Approximately 30% of the rigs are powered by electric or diesel-electric drives, used largely for development drilling. The latest model rigs are equipped with automatic controls and use pneumatic and hydraulically operated equipment such as breakout tongs and lifts for making up and breaking down the drill column.

4. Crude oil production 25X1

a. Output and plans — The Soviet Union is the second largest producer of crude oil in the world,

Figure 17. PRODUCTION OF CRUDE OIL 25X1
(Millions of tons)

YEAR	PLAN CONTROL FIGURES	REVISED ANNUAL GOALS	ACTUAL CRUDE OIL PRODUCTION	PERCENT OVER FULFILLMENT OF REVISED GOALS
1959	128.0	128.0	129.6	*1.2*
1960	144.3	144.3	147.9	*2.5*
1961	161.0	164.0	166.1	*1.3*
1962	180.1	185.0	186.2	*0.6*
1963	200.0	205.0	206.1	*0.5*
1964	*est* 220	222.0	223.6	*0.7*
1965	230 240	242.0	242.9	*0.4*
1966	264.0	264.0	265.1	*0.4*
1967	286.3	286.0	288.1	*0.7*
1968	309.0	309.0	309.4	*0.1*
1969 plan	326.5	...	...	...
1970 plan	345 355	...	...	...
1975 plan	450 470	...	...	...
1980 plan	600 620	...	...	...

being surpassed only by the United States. Total production of crude oil in 1968 amounted to about 309 million tons, 15% of total world output and equivalent to about 60% of crude oil production in the United States. Output of crude oil in the U.S.S.R. has doubled since 1960, reflecting an average annual growth rate of 10%. Cumulative above-plan performance in the production of crude oil amounted to 15.3 million tons during 1959-67 (based on revised annual goals). Figure 17 provides data on goals and actual output of crude oil during 1959-67 and plans for 1970, 1975, and 1980.

About 70% of the crude oil produced in the U.S.S.R. in 1967 came from the Urals-Volga region, known as the Second Baku. The rise in importance of the Urals-Volga region as a crude oil producer is shown in the following tabulation (in millions of tons and as a percent of the national total):

	Output	Percent of total
1940	1.8	*6*
1945	2.8	*15*
1950	11.0	*29*
1955	41.1	*58*
1962	134.1	*72*
1966	186.3	*70*
1967	201.6	*70*

One of the largest known oil deposits in the world was discovered at Romashkino during 1948-49 in the Tatar S.S.R. The geological structure is very complicated containing 5 oil-bearing zones with a total thickness of up to 35 meters. The deposit was divided into eleven separate producing areas, and each was developed as an individual field. The simultaneous production of oil and contour water flooding of the oil-bearing sandstone reservoirs to maintain pressure has permitted maximum extraction rates and recovery rates, with a minimum number of producing and injection wells. Crude oil production at Romashkino rose from 700,000 tons in 1951 to 70 million tons in 1967, or about 25% of total U.S.S.R. output. The average well productivity at Romashkino is 1,500 tons per month, compared to the U.S.S.R. average of 530 tons. Crude oil production costs in the Romashkino field are about 1.4 rubles per ton, approximately half the national average.

The productive Urals-Volga region has relegated the older producing regions, particularly the Baku fields of Azerbaydzhan S.S.R., to a less important position. The Baku fields and other Transcaucasus fields produced only 9% of the national output in 1966, compared to 71% in 1940. Estimates of crude oil production by producing regions of the U.S.S.R. for 1940, 1950, 1960, and 1980 are given in Figure 18. The output of crude oil by economic regions in the U.S.S.R. in 1967 is illustrated on Figure 75. Figures 19 through 22 show oilfield equipment and activities.

After 1970 the relative importance of the Urals-Volga region is expected to decline as greater reliance is to be placed on output from new deposits in Western Siberia and the Mangyshlak Peninsula in western Kazakhstan. These new producing regions are to supply at least 40% of the total production of crude oil by 1980. Plans call for the annual output in the U.S.S.R. to increase by 22 million tons during 1968-75 to reach the 1975 goal of about 460 million tons, and by 30

Figure 18. ESTIMATED OUTPUT OF CRUDE OIL, BY PRODUCING REGION 25X1
(Percent of total)

OIL PRODUCING REGION	1940	1950	1966	1980*
Transcaucasus and Azerbaydzhan	*71*	*39*	*9*	*4*
Northern Caucasus	*15*	*15*	*10*	*6*
Urals-Volga	*6*	*29*	*70*	*40*
Central Asia and Kazakhstan	*5*	*12*	*5*	*15*
Ukraine and Belorussia	*1*	*1*	*3*	*7*
Others (West Siberia, Far East)	*2*	*4*	*3*	*28*
Total	*100*	*100*	*100*	*100*

*Estimate.

Figure 19. Rig floor operations at deep drilling site in Krasnodar Kray

Figure 20. Pumping oil well and work-over tower in Tuymazy oilfield (

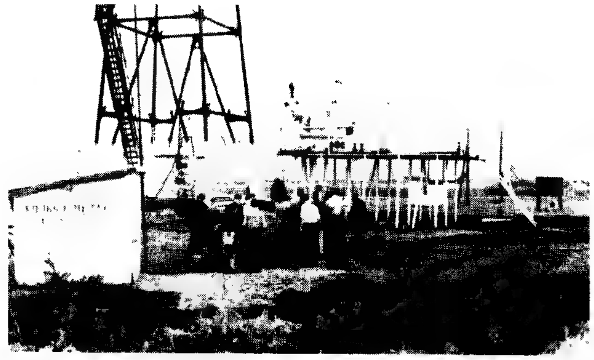
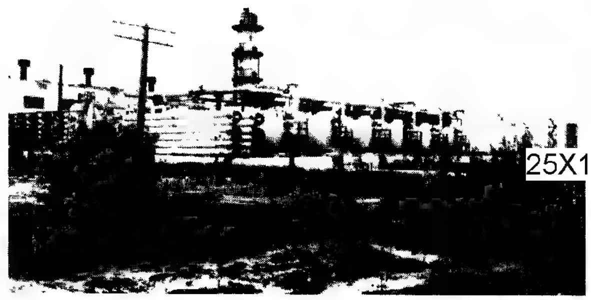


Figure 21. Flowing well with treater and storage tank in Tuymazy oilfield (25X1



25X1

Figure 22. Desalting unit at Tuymazy oil-fiel 25X1

million tons during 1976-80 to reach the 1980 goal of 600-620 million tons.

b. Methods of production — In 1967, about 59% of the crude oil produced was obtained from free-flowing wells, about 39% from pumping wells, and most of the remainder from gas or air-lift wells. Of the 41,700 wells producing in 1966, however, only about 8,200, or 20%, were free-flowing whereas more than 33,000, or about 80%, were pumped wells. Production of crude oil in the U.S.S.R., by method of production, for 1950, 1955, 1961, 1964-67 is given in Figure 51. Plans for 1970 call for annual production of crude oil from free-flowing wells to reach more than 200 million tons and the number of free-flowing producing wells is to be more than 12,000.

The use of submerged electric centrifugal pumps in oil producing wells began in the U.S.S.R. in 1951. About 3,400 bottom hole pumping units were in operation in 1966 and output of crude oil from wells using this equipment amounted to 48 million tons, or 18% of total output. In 1966, about 30,000 wells in the U.S.S.R. were equipped with conventional rod-type pumps and accounted for about 14% of total crude oil output. Plans for 1970 call for the use of almost 9,000 submersible pumps in producing wells that are to yield about 100 million tons of crude oil, or at least 30% of total output. The number of rod type25X1s in use in 1970 is expected to be one-third larger than in 1966, and output from wells equipped with rod pumps should reach 55 million tons, or almost 16% of national production.

c. Means for increasing output — Since 1948, primary production and water flooding (both contour and intra-contour) have been started simultaneously. The flooding, which continues throughout the life of the field, maintains reservoir pressure, prolongs producing life, optimizes the free-flowing production rates for each well and field, minimizes the number of wells to be drilled, and increases the ultimate recovery of crude oil. The amount of water injected annually into producing reservoirs increased from about 142 million cubic meters in 1958 to more than 360 million cubic meters in 1966. The number of water flood injection wells during that period rose from about 3,000 to 4,100. The total output of crude oil from fields in the water flooding programs in 1958 amounted to about 70 million tons, or about 62% of national output. In

1966 the share of national output from fields where water flooding was used was estimated at more than 80%.

In addition to development drilling and water flooding, other methods are being used to increase the production of crude oil. They include artificial stimulation and rejuvenation of crude oil reservoirs by hydraulic fracturing and acidizing the producing formations; and secondary recovery methods using steam flooding, fire flooding, and chemical reagents. Acidizing and hydraulic fracturing are used to increase the flow of oil from tight formations. The secondary methods are normally employed when the natural reservoir drive (either water or gas or a combination of both) has declined. No information is available on the amount of crude oil obtained by the above-mentioned methods, but it probably is small—less than 1% of total output. The U.S.S.R. also has contemplated and perhaps made use of nuclear explosions for the stimulation of tight reservoirs, but no data are available on any results that may have been achieved.

d. Offshore production — Up to the present time Soviet offshore production of crude oil has been concentrated in the Caspian Sea, in the shallow waters surrounding the Baku Archipelago. Production from these offshore fields has provided most of the gains in output in Azerbaydzhan in the postwar period. In 1966 offshore wells produced nearly 12 million tons or about 55% of the 21.7 million tons of crude oil produced in Azerbaydzhan. The average yield of offshore wells near Baku is almost 3 times that of the average in Azerbaydzhan and is attained at a cost 30% to 35% lower than for onshore wells. Typical offshore wells and facilities are shown in Figures 23 and 24.

The major limitation to the expansion of crude oil production from offshore deposits has been a lack of equipment suitable for operation in deep water. Most of the offshore output has been limited to wells directionally drilled from onshore locations and from fixed platforms often connected to the mainland by trestles. Most of the offshore wells now in production are located in less than 30 meters of water and operations from fixed platforms are restricted to water depths of no more than 40 meters. About half of the areas of the Caspian Sea considered favorable for petroleum production lie under water depths in excess of 100 meters. Before these deeper areas can be exploited the U.S.S.R. must develop more advanced offshore drilling technology and floating drilling platforms.

In 1959 the U.S.S.R. built its first offshore floating drilling platform the "Apsheron" which drilled about 50 shallow structural prospecting wells for mapping purposes. This first Soviet floating platform, which resembles early U.S. designs, is equipped with 4 tubular legs that can be lowered to the sea floor after the platform has been towed to the drill site. Western platforms of this type have been used, for the most part, in water depths of less than 100 meters. The "Apsheron" has drilled five wells less than 1,200 meters deep and is preparing to drill a sixth to a maximum depth of 1,800 meters in 15 meters of water. Construction of a second floating platform, the "Azerbaydzhan," is nearing completion. It will have a capability to drill to depths of 3,000 meters in 30 meters of water.

A most important acquisition of western offshore drilling equipment was made in September 1967, when the U.S.S.R. imported a drilling platform (named the "Khazar") from the Netherlands. The "Khazar" is a modification of a 5- or 6-year-old Royal Dutch Shell platform used in the Persian Gulf. This platform will

Figure 23. Ostrov Artem offshore oil wells

25X1

FIGURE 24. GAS SEPARATION UNIT AT OSTROV ARTEM OFFSHORE OILFIELD

25X1

permit Soviet technicians to drill 6,000 meter wells in water 60 meters deep. The "Khazar" will greatly facilitate Caspian Sea exploration off the Baku Archipelago, along the Iranian shoreline and along the east shoreline of Turkmenistan, where numerous prospects are believed to exist.

Ultimately, the U.S.S.R. will need more advanced floating platforms. U.S. industry has used platforms held in a stable floating position, by means of auxiliary propellers and anchors, for drilling in water 180 meters deep. In the fall of 1968 the U.S. had built such a platform capable of drilling in water 300 meters deep.

e. NEW CRUDE OIL DISCOVERIES AND THEIR SIGNIFICANCE — Recent crude oil discoveries of major proportions have been recorded on the Mangyshlak Peninsula of western Kazakhstan and in the Tyumen and Tomsk Oblasts of West Siberia. The reserves of these new shallow multizone deposits are potentially very important for future crude oil supply. Soviet planners currently estimate that in 1980 about 200 million to 220 million tons of crude oil, one-third of total production, will come from fields located east of the Ural Mountains, in the Western Siberian Lowlands, and from fields of the Mangyshlak Peninsula in western Kazakhstan. The European portion of the U.S.S.R., however, consumes about 80% of the fuel used in the country. The problems associated with the transportation of rising volumes of crude oil over great distances from east to west will require significant expansion of the present petroleum pipeline system and less reliance on transport by railroad tank car.

Several technological problems must be resolved and special equipment will be needed to attain the production levels planned for the new fields in Central Asia and in Western Siberia. Problems of terrain ranging from arid deserts to arctic tundra suggest that automation and remote control devices will be needed for the operation of new fields, treating facilities, gathering systems, storage sites, and pipelines. Moreover, Mangyshlak crude oil has a high paraffin content and must be kept in storage or in transit at temperatures above 32 degrees Centigrade (90 degrees Fahrenheit) or it will solidify and cease to flow.

f. PRODUCTION COSTS — The average cost of producing crude oil in the U.S.S.R. declined about 30% during the past decade, from 4.1 rubles per ton in 1956 to 2.8 rubles per ton in 1966 (the equivalent of 42 cents per barrel). These costs, however, do not include expenditures for prospecting and exploratory drilling. Exploration costs alone are estimated to range from 0.65 rubles per ton in the Urals-Volga region to more than 3 rubles per ton in the Far East. Costs of production and development of reserves by major producing regions in the U.S.S.R. in 1966 are given in Figure 52.

5. Refining

25X1

a. CAPACITY — As of 1 January 1968 the U.S.S.R. had a total crude oil charge capacity (primary distillation capacity) of about 255 million tons per year,[6] a capability exceeded only by that of the U.S. This Soviet capacity is contained in about 50 separate refineries with almost 60% concentrated in the Urals-Volga region and in the European part of the country. Most of the refining processes employed in the west are in use in the U.S.S.R. but Soviet operational experience in some of them is limited. Locations of the major Soviet refineries, estimates of primary capacity, and available information on secondary capacities are given in Figure 53.

[6] One million metric tons per year equals approximately 20,000 barrels per day.

Soviet primary distillation capacity is not adequate to process all of the indigenous crude oil produced. According to the original Seven Year Plan (1959-65) primary capacity was to have reached 250 to 260 million tons in 1965. This capacity would have been adequate to process the 243 million tons produced in that year. During the seven year period, however, the U.S.S.R. began to export significant quantities of crude oil and as a result construction goals were lowered so that excess primary distillation capacity would not be built.

Unlike the U.S. and other industrialized countries of the Free World, the relative share of secondary capacity—catalytic cracking and reforming, hydrocracking, hydrogen treating, alkylation, isomerization, polymerization—in Soviet refineries is small. These secondary facilities are necessary to improve product quality and to increase flexibility of the product mix. Soviet secondary capacity probably does not exceed 20% of primary capacity, whereas in the U.S. secondary capacity is at least equal to primary capacity. It must be pointed out that in the past such processes as catalytic cracking and reforming were not as necessary in the U.S.S.R. as in the west because there was no great demand for high octane gasoline in the Soviet economy. Nevertheless, as the need for higher quality products has increased in recent years, the construction of secondary processing facilities has been undertaken. During 1959-65 the construction of these facilities lagged badly because of poor planning and inadequate allocation of investment funds for the manufacture of the necessary equipment. During the present Five Year Plan (1966-70) considerable emphasis is being placed on the construction of secondary refining units. By the end of 1970 the capacity of secondary facilities is to reach at least 100 million tons per year, or about one-third of the anticipated 300 million tons of primary capacity. Estimated capacities of known secondary refining facilities in the U.S.S.R. in 1965 and as planned for 1970 are given in Figure 54.

b. Location of capacity — Before World War II most of the refining capacity in the U.S.S.R. was centered in the Caucasus, reflecting the position of this region as the major crude oil producing area. In the 1950's most new capacity was built in the Urals-Volga region which had become the major producer of crude oil. In recent years, however, Soviet policy on the location of refineries has changed. Refineries are now being built in areas of increased demand, especially in the European part of the U.S.S.R. Nevertheless, the Urals-Volga region remains the largest center of refining capacity, but its share of total capacity probably will decline in the future. There is also a sizable concentration of capacity in a relatively few large refining sites. For example, in 1967 almost three-fifths of total primary distillation capacity was concentrated at 8 locations, as shown in the following tabulation:

Location	Primary distillation capacity	Percent of total Soviet primary capacity
	Million tons	
Kuybyshev	27	*10.6*
Ufa	26	*10.2*
Baku	24	*9.4*
Omsk	20	*7.8*
Groznyy	13	*5.1*
Angarsk	12	*4.7*
Polotsk	12	*4.7*
Yaroslavl	12	*4.7*
Total	146	*57.2*

The estimated geographical distribution of primary distillation capacity in the U.S.S.R. at the end of 1967 is summarized in Figure 55, and shown on the map, Figure 76. The Polotsk refinery is shown in Figure 25.

c. Refinery construction practices — Traditionally, Soviet efforts in the construction of refineries have been dispersed over a large number of projects and construction times have been extremely long compared to the time that equivalent construction would require in the United States. Such delays, coupled with rapid technological progress in oil refining, tended to make much of the equipment obsolete before it went on stream. In the period before the Seven Year Plan (1959-65) the norm in the U.S.S.R. for construction of a standard design refinery with an annual crude oil charge capacity of 6 million tons was 7.5 years, but actual construction usually exceeded this time. After 1959 the construction norm for such a re-

Figure 25. Polotsk refinery in Belorussian S.S.R.

25X1

finery was reduced to 3 to 4 years which more nearly conformed to western practice. Efforts also were concentrated on a smaller number of projects at any one time.

In 1963 the U.S.S.R. was particularly active in attempting to purchase all types of refining processes from the industrialized countries of the Free World. The U.S., Japan, Italy, the Netherlands, the U.K., and West Germany were asked by the U.S.S.R. to submit bids on essentially the same integrated refinery—a plant with a crude oil charge capacity of 12 million tons per year to contain the most advanced equipment and refining processes available. The projected refinery, valued at $300-360 million if built by U.S. firms, was to have been installed about 100 kilometers southeast of Moscow and was to process Urals-Volga crude oils. This refinery probably would have served as a prototype for a number of refineries to be built in the U.S.S.R. in the coming years. No contract was concluded, however, for the construction of such a refinery, but Soviet interest has continued in acquiring western technology and equipment. For example, several contracts were signed during 1966-67 with France for the import of catalytic reforming and hydrogen treating installations.

During 1959-65 much of the increase in refining capacity was attained by the modernization and more intensive use of existing facilities. Construction of new refineries during these years lagged. For example, two of the major new refineries—Kirishi and Kremenchug—that were originally scheduled for completion in 1964 and in 1965 did not go on stream until mid or late 1966.

d. Refinery equipment — The lack of oil refining equipment in the U.S.S.R. probably was a major factor in failure to build new and modern facilities on schedule. As shown in the following tabulation, output reached a peak in 1953, then inexplicably declined and did not regain the 1953 level of output until 1962. Despite the sharp gains in output during 1961 and 1962 delivery of equipment to refineries fell short of plan by about 25,000 tons as output was diverted to more important consumers, presumably the chemical industry. After a 5% decline in 1963, production rose to a maximum in 1966 and then declined about 5% again in 1967. The goal for 1970 will be difficult to achieve if past performance is any criterion.

Year	Output of refinery equipment	Year	Output of refinery equipment
	Thousands of metric tons		*Thousands of metric tons*
1953	121.3	1964	139.6
1955	48.8	1965	139.7
1957	60.1	1966	147.5
1959	76.5	1967	140.2
1961	106.8	1968	125.0
1962	121.2	1970 plan	210–240
1963	114.8		

Because the domestic supply of refinery equipment is inadequate, the U.S.S.R. has been forced to import such equipment to maintain its construction program. Since 1960, at least, the Soviet Union has been a net importer of refinery equipment. Although no details are available on the types of equipment traded by the U.S.S.R. in recent years, imports of refinery equipment, primarily from Rumania and Czechoslovakia, rose from about the equivalent of US$1.3 million in 1960 to a maximum of about the equivalent of US$30 million in 1965. During 1960-66 small amounts of refinery equipment have been exported, primarily to Eastern European Communist countries. Available information on Soviet trade in refinery equipment during 1960-66 is given in Figure 56.

e. Output of products — The refining of crude oil in the U.S.S.R. has always emphasized a high percentage yield of the intermediate distillates, kerosene and diesel fuel. Since 1958 diesel fuel has been the basic product obtained from Soviet refineries. Because of the limited use of passenger automobiles in the U.S.S.R. the demand for gasoline has been relatively limited and the percentage yield of gasoline since 1958 has averaged only about 18% of total product output, compared to more than 40% in the United States. Despite the relatively low yield from refining, more gasoline has been produced than could be used efficiently and in some instances excess low quality straight-run gasoline was blended with diesel fuel to increase the output of diesel fuel and to lower the freezing point of the diesel fuel used in cold weather service.

The estimated annual yields of petroleum products in the U.S.S.R., by type of product, for the years 1958-67 are summarized in Figure 57. Total output of refined products rose from about 92 million tons in 1958 to 202 million tons in 1967, an increase of 121%. The importance of diesel fuel in the economy has been reflected in the 11% average annual rate of increase in output during the past 9 years, from about 21 million tons in 1958 to about 56 million tons in 1967. The yield of diesel fuel has risen during these years from about 21% of total crude oil charged to refineries in 1958 to about 25% in 1967. Increased output of diesel fuel has been necessitated by the growing use of diesel equipment in agriculture and transport. The relative decline in the yield of kerosene reflects for the most part the replacement of kerosene fueled tractors by diesel tractors. This decline, however, has been offset somewhat by the growth in demand for jet fuel.

The output of residual fuel oil (mazut) has exceeded that of any other product in Soviet refining. The extensive need for this product in industry, especially for generation of electric power, brought about an increase in its yield from about 29% of total crude oil charged in 1955 to 34% in 1965. It is expected that as increased secondary refining capacity becomes

available there will be a greater demand for light and middle distillates of high quality and the yield of mazut will decline. Moreover, some of the mazut consumed in industry will be replaced by natural gas.

The yield of lubricating oils has remained nearly constant (about 3.5% of total output) during the past 9 years but output has more than doubled. The U.S.S.R. claims to be self-sufficient in the supply of lubricating oils and greases but the production of additives for these products has lagged behind domestic needs.

The quality of gasoline and diesel fuel has suffered because of the lack of secondary facilities. Construction of secondary units of all types will be required to meet future domestic and export needs for high quality products. Plans call for raising octane numbers of motor gasoline to 92 and 98 and for reducing the sulfur content of diesel fuels from 1% to 0.2% by weight.

f. Quality of crude oils — It has been reported that the majority of Soviet refineries receive crude oil containing 1% to 3% water and sediments and as much as 700 pounds of salt per 1,000 barrels of oil. In addition, a large share of Soviet crude oils contains a rather high sulfur content (1% to 3%, by weight). The chronic shortages of desalting and dehydration equipment in oilfields necessitates the uneconomic shipment of highly corrosive impurities to the refinery. Thus the use of extensive electrolytic and chemical desalting and dehydration units at the refinery adds to the processing costs that must be borne by the refiner. The construction of catalytic hydrogen treating units also has been required to lower the sulfur content of the distillates produced.

g. Synthetic oil facilities — The output of synthetic oils in the U.S.S.R. has been deemphasized in recent years. Processing facilities for such production were centered in the rich and prolific oil shale region of the Estonian S.S.R. and in the coal producing area of Siberia near Lake Baikal (both fuel-short regions). The U.S.S.R. has been producing oil shale in the Estonian S.S.R. for more than 20 years and has been engaged in research to improve oil shale mining techniques and retorting methods. In 1967 the U.S.S.R. produced almost 22 million tons of oil shale; about 16 million tons were produced in the Estonian S.S.R. and the remainder from deposits in the R.S.F.S.R., mostly near Kuybyshev in the Urals-Volga region. In recent years major emphasis has been placed on using oil shale as a powerplant fuel and for production of gas and chemicals rather than on producing shale oil. It is estimated that a maximum of 250,000 tons of shale oil were produced in 1967 and the level of output probably will decline in the future.

A coal liquefaction plant was built near Angarsk in the mid-1950's with equipment transported from Germany after World War II. Although this plant produced oil products for several years, it is believed that the primary output now is chemicals. Since a new petroleum refinery at Angarsk came on stream in 1960, processing Urals-Volga crude oil, the needs of Eastern Siberia for oil products have been supplied by this refinery.

h. Plans for expansion of capacity — Plans for the 1966-70 period provide for the allocation of 6.6 billion rubles to the oil refining and petrochemical industries, about twice as much as was allotted to these industries during the previous 5 years. Primary distillation capacity will have to be increased by about 15 million tons per year to reach the level of 300-million-ton capacity anticipated by the end of 1970. Nine large primary distillation units are scheduled to be built during the current Five Year Plan. About 70% of total additions to refining capacity during 1966-70 are to be provided at plants in operation or under construction and the remaining 30% at new refineries to be built. Crude stills with annual capacities of 6 million tons have been installed at the new refineries at Kirishi and Kremenchug. Units of about the same size are to be installed at most of the refineries under construction or to be built by 1970. Future plans are being considered for the construction of primary distillation units with capacities of 12 million tons per year and eventually of 18 million tons. Installation of these larger primary units will require less investment than would be necessary to install an equivalent amount of capacity in smaller units. It also will facilitate the construction of larger and more economical secondary processing units to improve product quality. A recent plan calls for construction of a 6-million-ton-per-year standard refinery to include atmospheric and vacuum distillation, catalytic reforming, hydrogen treating, and hydrocracking units. This type of plant is to be built by 1975 with a capital investment of 40-45 million rubles.

Plans for the expansion of secondary processing facilities are of major importance in the refining industry. Catalytic reforming will be needed to increase the octane rating of gasoline; by 1970, about 40% of total demand will be for 85 octane motor gasoline, compared with only about 10% in 1965. By 1970 the output of passenger cars that require high octane gasoline will be three times the number produced in 1965. Soviet reports indicate that about 7 catalytic reformers were in operation at the end of 1965 with a maximum capacity of 3 million tons per year. Plans for 1970 call for the construction of 15 new catalytic reforming units that will be twice as large as those built in previous years. Recent claims in the Soviet press and technical journals reveal that a modification of the catalytic reforming process has been made and a better catalyst has been developed. It is likely that the old hydroforming process using a metallic oxide catalyst was abandoned and that technology involving the use of a platinum catalyst was adopted.

Extensive use of hydrogen treating is to be made to lower the sulfur content of diesel fuels and to re-

duce sulfur in the naphthas charged to the catalytic reformers. With the application of this process by 1970, 90% of the diesel fuel produced is to contain no more than 0.2% sulfur whereas in 1965 the average sulfur content in this product was about 1%.

During 1966-70 catalytic cracking capacity is to be increased 1.5 times. No data are available on the capacity or numbers of catalytic cracking units in operation at the present time. From observations made by western technicians in 1960 small-sized fluid-type units were then in use and larger units were under construction. Catalyst plants producing silica-alumina catalysts for domestic cracking units are known to exist at Omsk and Baku. No details are available on the quantities of catalysts produced.

The most flexible and useful secondary process for the U.S.S.R. is hydrocracking. This process would be especially valuable for use in processing the high sulfur stocks so prevalent in the U.S.S.R. Recent announcements in the Soviet press claim that a high pressure hydrocracking process for handling high sulfur residual oils has been developed and equipment is to be installed. However, Soviet technical magazines have indicated that the hydrocracking process has not been mastered on a commercial scale.

6. Transportation

a. General — Transportation of petroleum in the U.S.S.R. has been, and continues to be, a major problem because of the concentration of crude oil production and refining in a relatively few, but not necessarily coincident, regions and the vast distances which separate these regions from the centers of consumption. Railroads have continued to play the largest role in the movement of petroleum despite continuous efforts to have pipelines become the dominant mode of transport. Although the share of pipelines in oil movement has increased more rapidly than the share of other means of transport since 1955, the plans for construction of oil pipelines have not been fulfilled in recent years because greater priority has been allocated to the building of the natural gas pipeline system. As shown in Figure 58, which gives data on transport of petroleum in the U.S.S.R. by type of carrier, pipelines accounted for about 26% of the total volume (in ton-kilometers) of oil freight in 1965, compared to less than 10% in 1955. During the same period the movement by railroads declined from almost 66% to about 50%. No data are available on the movement of oil by tank trucks used to haul crude oil from isolated producing wells to gathering pipelines. About 22 million tons of petroleum products were hauled by common carrier motor transport in 1965.

b. Pipelines — The total length of the oil pipeline network in the U.S.S.R. at the end of 1968 was about 33,000 kilometers. At least 80% of the system consisted of crude oil pipelines and the remainder, of product lines. During the postwar years there has been a considerable effort to expand the oil pipeline network to supplant the more expensive movement of oil by rail. However, the annual goals for construction of oil pipelines have failed to meet plans since 1955. At first the shortfalls were relatively minor but around 1960 priority was assigned to the construction of natural gas pipelines at the expense of the oil pipeline program. At the end of 1965 about 28,000 kilometers of oil pipelines had been built whereas the original goal of the Seven Year Plan had called for the system to total about 43,000 kilometers. The plan for this 7-year period called for: building oil pipelines to link all the major oil refineries with the crude oil producing fields; completing the Friendship crude oil pipeline system to Eastern Europe; and constructing crude oil and product pipelines to Baltic and Black Sea ports to facilitate Soviet exports of oil. A list of the major crude oil and product pipelines built during 1959-67 is given in Figure 59. Major oil pipelines are shown on Figure 77. General data on the postwar development of the oil pipeline network, including tons of oil carried and ton-kilometer movements are given in Figure 26.

Plans for 1970 call for the oil pipeline system to be increased to approximately 41,000 kilome25X1r about 13,000 kilometers more than in 1965. The volume of oil to be moved by pipeline in 1970 is to be almost double that in 1965. The future need for oil pipeline construction is especially great in view of the development of prolific new deposits in Western Siberia and Central Asia that are remote from major refinery and consuming centers. The most important crude oil and product pipelines scheduled for completion during 1968-75 are listed in Figure 60. The use of larger diameter lines to transport larger volumes of oil at lower unit costs also will be necessary to move crude oil and petroleum products over greater distances. Domestic supplies of large diameter pipe are not adequate to provide the needs of both the oil and gas industries. Imports of such pipe will be required from western and eastern Europe to meet pipeline construction goals. The throughput capacity and cost

Figure 26. Postwar Development of Oil Pipeline Transport 25X1

Year	Total length of oil pipelines	Tons carried	Ton-kilometers
	Kilometers	*Million*	*Billion*
1945	4,400	5.6	2.7
1950	5,400	15.3	4.9
1955	10,400	51.7	14.7
1960	17,300	129.9	51.2
1965	28,200	225.7	146.7
1966	29,500	247.7	165.0
1967	32,400	273.3	183.4
1970 plan	41,100	452	300

of transporting oil via pipelines of varying diameters are given in Figure 61.

c. Other means of transport — Movement of oil by railroad tank car accounts for more than half of total oil transport in the U.S.S.R. With the shortfall in the pipeline construction program any extra petroleum traffic resulting from overfulfillment of oil production plans or increased regional demands for oil normally is handled by the railroads. This increased burden on the railroads creates occasional bottlenecks in supply and adds to the overall cost of transporting oil. Data on the amount of oil shipped by rail and the average distance hauled are given in Figure 62. Maritime and inland water transport accounts for about 15% of the total amount of oil transported in the U.S.S.R. Liquid cargoes accounted for less than half of total Soviet shipments by sea in 1966 and almost all liquid cargo is estimated to be oil. Information on the transport of oil by inland waterway is given in Figure 62.

7. Foreign trade

25X1

Since 1955 the U.S.S.R. has been a net exporter of petroleum in steadily increasing amounts. Net exports rose from about 4 million tons in 1955 to approximately 77 million tons in 1967, an average annual increase of about 29%. Details of Soviet trade in crude oil and petroleum products for the years 1955 and 1959-67 are given in Figure 63.

a. Exports — In the period since 1960 about 55% of total Soviet exports of petroleum were shipped to Free World countries. The greatest portion of this oil has been sold to industrialized countries of the west to earn foreign exchange to import technology and equipment. In 1967, for example, it is estimated that Soviet exports to the Free World were valued at about US$510 million. Of this amount the equivalent of approximately US$340 million was in hard currency. During 1966 and 1967 all of the increase in Soviet sales of petroleum to the Free World was in exports to the developed countries, primarily to Western Europe. Exports to the less developed countries declined during these 2 years.

At least three-fourths of Soviet exports of oil to other Communist countries have been delivered to the nations of Eastern Europe. Most of the petroleum supplied to Eastern Europe is crude oil delivered via the Friendship pipeline. Growing needs for oil in Eastern Europe and in the U.S.S.R. may inhibit any future rise in the annual rate of increase in Soviet exports of oil to the Free World. In 1967 the 6.5% increase in Soviet exports to the Free World was the smallest annual rate of growth since 1955; this may presage a future trend.

The composition of Soviet exports of petroleum has changed considerably during the past 9 years. In 1959, crude oil and petroleum products represented almost equal shares in total exports. As refining capacity in the Free World and in other Communist countries has expanded, the demand for crude oil has risen more rapidly than that for products. Thus, in 1966 and 1967 exports of Soviet crude oil accounted for more than two-thirds of total petroleum exports. This trend is expected to continue in the future. Figure 27 gives details of Soviet exports of petroleum to the Free World and other Communist countries for selected years since 1955.

Exports of petroleum from the U.S.S.R. have represented a rising share of indigenous production of crude oil. In 1960 total oil exports were equal to about 22% of total output of crude oil whereas by 1967 this share had risen to about 27%.

b. Imports — Official Soviet trade statistics show that imports of petroleum declined from about 4.4 million tons in 1955 to less than 1.4 million tons in 1967. It is probable that most of the oil products did not, in fact, enter the U.S.S.R. but were delivered to other Eastern European Communist countries, primarily from Rumania, on the Soviet account. Some small quantities probably were shipped from Rumania to the contiguous areas of the U.S.S.R. (Moldavian S.S.R., for example) which can be supplied more economically from Rumania than from domestic refineries in the Ukrainian S.S.R. Also, the crude oil reported to have been imported by the U.S.S.R. through 1963 was actually Austrian crude oil shipped

Figure 27. EXPORTS OF PETROLEUM

25X1

(*Millions of tons*)

YEAR	EXPORTS TO FREE WORLD COUNTRIES			EXPORTS TO OTHER COMMUNIST COUNTRIES			GRAND TOTAL EXPORTS
	Crude oil	Products	Total	Crude oil	Products	Total	
1955	0.7	3.1	3.8	2.2	2.0	4.2	8.0
1959	6.1	7.1	13.2	6.4	5.8	12.2	25.4
1960	9.0	9.1	18.1	8.8	6.3	15.1	33.2
1962	13.6	11.1	24.7	12.7	8.0	20.7	45.4
1964	18.8	12.5	31.3	17.9	7.4	25.3	56.6
1965	21.0	14.5	35.5	22.4	6.5	28.9	64.4
1966	24.8	16.5	41.3	25.5	6.8	32.3	73.6
1967	26.7	16.8	43.5	27.3	8.0	35.3	78.8
1968*	26.4	16.9	43.3	31.0	8.0	39.0	82.3

*Preliminary.

to Eastern European Communist countries on Soviet account as part of the Soviet-Austrian reparations agreement.

8. Consumption

During 1959-67 the apparent domestic consumption of petroleum products in the U.S.S.R. more than doubled, increasing from almost 88 million tons in 1958 to about 187 million tons in 1967. During the same period, exports of petroleum products rose from 9 million tons to about 25 million tons and the allocation of petroleum products from total supply to meet domestic needs declined from about 91% in 1958 to 88% in 1967. A simplified supply and demand balance for petroleum products in the U.S.S.R. for selected years during 1958-67 is given in Figure 28.

a. By type of product — The supply of petroleum products, in general, has been adequate to satisfy the steadily growing domestic demand. There is, however, some inflexibility in refinery operations resulting at times in a range of product output that does not satisfy seasonal variations in demand; consequently, sporadic shortages of oil products occur. Shortages also result from insufficient transport facilities during peak periods of consumption as, for example, at harvest time when railroad facilities are overburdened supplies of diesel fuel are not always adequate. The supply of diesel fuel, the basic fuel in the Soviet economy, has been tight, partially because 10% to 15% of the total output has been exported to earn foreign exchange. The estimated consumption of diesel fuel rose from about 18 million tons in 1958 to almost 45 million tons in 1966 due to increased demands by agriculture and transport.

It has been reported in recent years (1966-67) th25X1 36% of the Soviet supply of diesel fuel and 28% of the motor gasoline supply are consumed in agriculture. In 1967 the estimated quantities of diesel fuel and gasoline consumed in agriculture would approximate 21 million and 11 million tons, respectively. Estimates of consumption of petroleum products in the U.S.S.R. for selected years, by type of product, are shown in Figure 64.

b. By consuming sector — It is estimated that the industrial sector uses about half of all the petroleum products consumed in the Soviet economy. The three major consuming sectors—industry, agriculture, and transport—probably accounted for about 87% of total consumption of oil products in the U.S.S.R. in 1966. As shown in Figure 29 the relative share of consumption by industry since has risen, those of agriculture, transport, and communal-household have remained about the same, and that of other consumers has declined.

9. Storage

25X1

a. Crude oil — The storage capacity for crude oil in the U.S.S.R. probably averages at least 10% of the annual production. Thus, at the end of 1967 total crude oil storage capacity approximated 30 million tons. Most of this capacity is at oilfield installations and refineries; however, some transfer oil bases handle

Figure 28. SUPPLY AND DEMAND FOR PETROLEUM PRODUCTS 25X1
(*Millions of tons*)

	1958	1960	1962	1964	1965	1966	1967
Supply:							
Refinery output (nongas)	92.7	116.1	141.5	164.8	176.8	190.3	207.0
Imports	3.2	3.2	2.3	2.1	1.9	1.7	1.4
Natural gas liquids and synthetics	1	1	2	3	3	3	3
Total supply	96.9	120.3	145.8	169.9	181.7	195.0	211.4
Demand:							
Apparent domestic consumption	87.9	104.9	126.7	150.0	160.7	171.7	186.7
Exports	9.0	15.4	19.1	19.9	21.0	23.3	24.7
Total demand	96.9	120.3	145.8	169.9	181.7	195.0	211.4

Figure 29. ESTIMATED CONSUMPTION OF PETROLEUM PRODUCTS, BY CONSUMING SECTOR (U/OU)

CONSUMING SECTOR	1958		1965		1966	
	Million tons	Percent	Million tons	Percent	Million tons	Percent
Industry	39.5	*45*	80.3	*50*	85.8	*50*
Agriculture	17.6	*20*	32.2	*20*	34.3	*20*
Transport	14.1	*16*	27.3	*17*	29.2	*17*
Communal-household	2.6	*3*	4.8	*3*	5.2	*3*
Other (including military)	14.1	*16*	16.1	*10*	17.2	*10*
Total	87.9	*100*	160.7	*100*	171.7	*100*

crude oil in addition to petroleum products. Transit storage of crude oil in railroad tank cars, pipelines, river barges, tank trucks, and ocean tankers provides some unidentifiable portion of crude oil storage capacity.

b. Petroleum products — The storage capacity for petroleum products in the U.S.S.R. at the end of 1967 was estimated at 46 million tons, the equivalent of about 90 days of domestic consumption. Approximately 7 million to 8 million tons of this capacity was located at petroleum refineries, an amount equivalent to 12 to 14 days of refinery throughput during the year. The remainder of the capacity is located at primary and secondary storage bases and at military airfields.

Primary storage bases handle petroleum products in their movement from the refinery to local distribution points. The Main Administration for the Transport and Supply of Petroleum and Petroleum Products (*Glavneftesnab*) controls all of the primary storage capacity, except for a certain portion controlled by refineries. There are two types of primary storage bases, the transfer oil base and the distribution base. The transfer oil base is found at seaports, on the banks of navigable rivers, and in the areas of large railroad junctions. From the transfer oil base, crude oil and petroleum products move by pipeline, tanker, or barge to a distribution base. From this base the products are distributed by tank cars, barges, or tank trucks. Storage capacity at these primary storage bases is generally quite large and the period of storage usually is short.

The distribution base is the main link between the petroleum industry and the national economy. Storage capacity at these bases is much less than that at transfer bases and a smaller variety of products is handled.

Cylindrical steel storage tanks are the most common type used in the U.S.S.R. Most of these tanks are prefabricated at the factory and the side walls are delivered to the site in rolls, where they are unrolled and welded to the bottom. Oil storage tanks assembled from prefabricated rolls are shown in Figure 30. The U.S.S.R. also is installing underground tanks or partially buried tanks in precast reinforced concrete. Installation of this type of storage is done primarily for fire prevention and for insulation against daily temperature changes to minimize loss of volatile petroleum fractions, but it is also effective against blast and shock.

10. Natural gas and natural gas liquids 25X1

a. Natural gas

(1) *Production* — Within the past decade the Soviet Union has become the second largest producer of natural gas in the world, surpassed only by the United States. Production of natural gas in the U.S.S.R. in 1968 amounted to about 169 billion cubic meters, or almost 20% of total world output. The United States produced about 545 billion cubic meters in 1967, about 60% of total world output. Approximately 88% of total Soviet output of natural gas is obtained from natural gas wells (nonassociated gas) and the remainder is produced in association with crude oil at oil wells (associated gas). Soviet statistics on natural gas production, however, usually include gas made from coal and oil shale (manufactured gas), which has averaged about 1.7 billion cubic meters annually since 1959.

During 1959-67 the Soviet output of natural gas rose at an average annual rate of about 21%, but in only three of these years have the revised (downward) annual goals been fulfilled. Much of the shortfall resulted from lags in installation of compressors on existing pipelines, shortages of production and consuming equipment, and inadequate development of urban distribution systems. The original goal for production in 1970 (225 billion to 240 billion cubic meters) was revised late in 1967 to 215 billion cubic meters as it is apparent that the industry has not solved the problems that caused past underfulfillments. Data on planned and actual production of natural gas in the U.S.S.R. during 1958-68 and plans for 1969 and 1970 are given in Figure 31. A breakdown of total output during 1958-67 by associated and nonassociated gas is shown in Figure 32.

Development of natural gas fields and construction of gas pipelines have taken priority over investments in similar oil operations since 1958 when these functions of the oil and gas industries were separated organizationally. The rapid growth in production of natural gas was made possible by the discovery and development of large deposits conveniently located in the north Caucasus, eastern Ukraine, and to a lesser extent in the Urals-Volga regions. Although proved reserves of gas have increased significantly since 1958, the rapid growth in output has resulted in a lowering of the ratio of reserves to production from a 43-year supply in 1958 to a 14-year supply at the end of 1966.

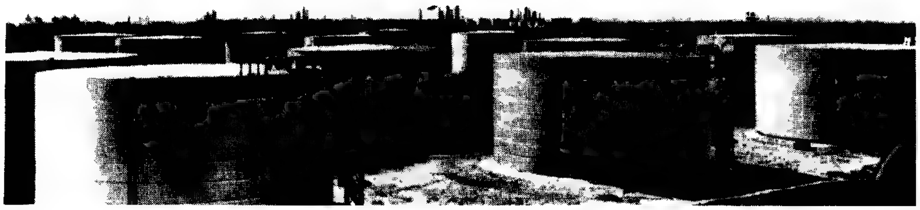


Figure 30. Storage tanks assembled from prefabricated rolls of sheet steel 25X1

25X1

FIGURE 31. PLANNED AND REPORTED PRODUCTION OF NATURAL GAS
(*Billions of cubic meters*)

YEAR	ORIGINAL PLAN	REVISED PLAN	REPORTED PRODUCTION	PERCENT OF PLAN (REVISED) FULFILLMENT
1958	30	30.0	28.1	*93.7*
1959		39.2	35.4	*90.3*
1960		51.5	45.3	*88.0*
1961		61.3	59.0	*96.2*
1962		70.5	73.3	*104.3*
1963		85.8	89.8	*104.7*
1964		*na*	108.6	*na*
1965	150	120.0	127.7	*106.4*
1966		146.3	143.0	*97.7*
1967		158.3	157.0	*99.4*
1968		171.3	169.3*	*98.8**
1969 plan**		185.8	....	....
1970 plan**	225 240	215	....	....

na Data not available.

*Preliminary estimate.

**Includes manufactured gas from coal and oil shale.

FIGURE 32. PRODUCTION OF ASSOCIATED AND NONASSOCIATED NATURAL GAS
(*Billions of cubic meters*)

25X1

YEAR	ASSOCIATED GAS	NONASSOCIATED GAS	TOTAL
1958	5.4	22.7	28.1
1959	6.5	28.9	35.4
1960	7.7	37.6	45.3
1961	8.6	50.4	59.0
1962	9.9	63.6	73.5
1963	12.1	77.7	89.8
1964	14.2	94.4	108.6
1965	16.5	111.2	127.7
1966	17.8	125.2	143.0
1967	18.9	138.6	157.5

The growth in reserves and output of natural gas during the 1957-66 decade was accompanied by a noticeable shift in production by geographical region. In 1956, about 85% of the nonassociated natural gas produced in the U.S.S.R. came from 5 regions. In 1966, output from these 5 regions had increased 170% over that in 1956, but their share of total output was only about 15%. The discovery of 4 prolific gas fields—Shebelinka (Kharkov Oblast), Krasnodar, Gazli (Uzbek), and Stavropol—during these years resulted in a significant increase in output with these new regions accounting for almost three-fourths of total output of nonassociated gas in 1966. The Soviet production of nonassociated natural gas, by region, for 1956 and 1966 is shown in Figure 65. The total number of wells and active producing gas wells in the U.S.S.R. in 1956 and 1966 is given in Figure 66. Drilling operations at a natural gas site in the Kalmyk A.S.S.R. is shown in Figure 33.

(2) *Costs of production* — Fixed costs account for the largest part of the total costs of producing natural gas. Costs for producing gas usually are lower than those for producing oil because gas wells do not need lifting equipment such as tubing, rods, and pumps. However, the surface installations for gas production, treating and transport require a much greater relative investment than those for crude oil.

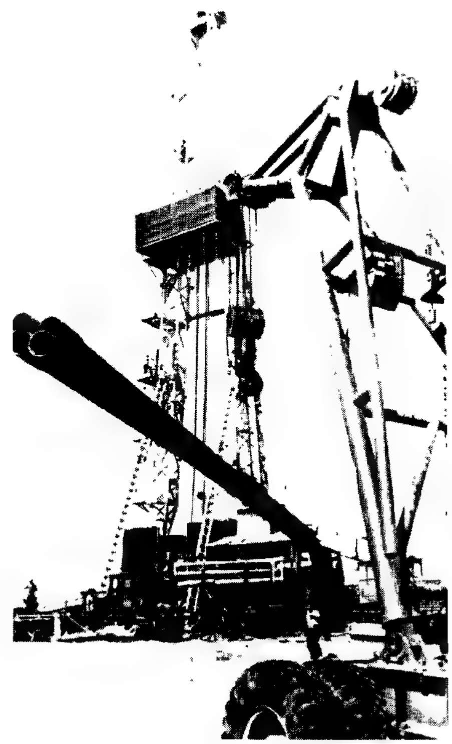


FIGURE 33. DRILLING RIG, NATURAL GAS WELL IN KALMYK A.S.S.R.

25X1

Capital costs can vary with well depths but the most significant cost factors are the number of wells drilled for maximum development and the productivity of each well, which determines the selection and quality of well-head fixtures and gathering systems. Construction of low-temperature natural gasoline separa-

tion units for processing condensate can greatly increase the average cost of production. For example, the removal of liquefied petroleum gases (LPG) separated from the methane streams produced at Shebelinka and Krasnodar caused average production costs to more than double.

The average cost of producing 1,000 cubic meters of natural gas in the U.S.S.R. during 1966 was 0.45 rubles, which is about 36% of the average cost in 1956. Soviet production costs do not include geological exploration expenditures made prior to development and therefore appear to be unrealistically low in comparison with U.S. costs. Exploration costs averaged 1 ruble per 1,000 cubic meters of natural gas produced as of mid-1967. The cost of producing natural gas varies from field to field and area to area. The lowest producing costs of 0.14 rubles per 1,000 cubic meters were recorded at the huge Gazli field in Uzbekistan S.S.R. and the North Stavropol field in Stavropol Kray. The average cost at Gazli is expected to double and that at Stavropol to triple in the near future as low-temperature separation equipment is to be added. A comparison of the average costs of production for each gas producing region in the U.S.S.R. in 1966 is shown as follows, in rubles per 1,000 cubic meters:

Gas producing region	Average cost of production
U.S.S.R.	0.45
Komi A.S.S.R.	2.61
Kuybyshev Oblast'	2.23
Saratov Oblast'	0.73
Volgograd Oblast'	0.58
Astrakhan Oblast'	0.70
Krasnodar Kray	0.52
Stavropol Kray	0.14
Tyumen Oblast'	5.59
Kharkov Oblast'	0.32
Poltava Oblast'	0.81
Lvov Oblast'	0.45
Ivan-Frankovo Oblast'	0.60
Uzbek	0.23

During 1971-75 the average cost of producing 1,000 cubic meters of gas in the U.S.S.R. is expected to rise almost 85% to a level of 0.83 rubles. Greater utilization of associated gas and further exploitation of gas-condensate deposits will greatly intensify capital investment requirements after 1970. Also, in older fields, declining reservoir pressures will require the construction of a greater number of compressor stations in order to repressure depleted gas reservoirs and maintain existing production levels. Data on costs of extraction and average capital investment by region in the U.S.S.R. during 1971-75 are given in Figure 67.

(3) *Transportation* — Pipelines are the only economical means for transporting natural gas. In the U.S.S.R. the expansion of the gas pipeline system has been a priority goal to facilitate the production and consumption of gas in the economy. During the Seven Year Plan period (1959-65) almost 30,000 kilometers of gas pipelines were built and shipments of gas rose from about 13 billion cubic meters in 1958 to about 109 billion in 1965. Most of the remainder of the gas not shipped by pipeline probably consists of propane or butane from associated natural gas and is transported in containers (bottled gas) by rail, inland waterway, or road. The expansion of the Soviet gas pipeline network annually since 1950 is shown in the following tabulation:

	Kilometers (at end of year)
1950	2,213
1955	4,861
1958	12,202
1959	16,494
1960	20,983
1961	25,328
1962	28,492
1963	33,033
1964	36,908
1965	41,800
1966	47,400
1967	52,600
1968	56,000
1970 plan	70,000

The average capacity of natural gas pipelines has increased in recent years with the use of larger diameter pipe. The following tabulation gives throughput capacities of the various diameter gas lines used in the U.S.S.R.

Diameter: *Millimeters*	Diameter: *Inches*	Annual throughput capacity*: *Billion cubic meters*
325	13	0.5
377	15	0.7
426	17	0.9
529	21	1.4
630	25	2.0
720	28	4.5
820	32	5.8
920	36	7.3
1,020	40	10.0
1,220	48	15.0
1,420	56	22.5

*At an operating pressure of 780 pounds per square inch.

When the first 720-millimeter gas line was put into operation in 1956, its throughput capacity exceeded by almost 40% the total throughput capacity of all other major gas pipelines in the U.S.S.R. More than half of the gas transmission lines in operation in 1967 were 720 millimeters or more in diameter compared to only about one-fourth of the total in 1958. In 1962 the first gas pipeline using 1,020-millimeter line pipe was completed from Krasnodar to Serpukhov. Many of the major trunklines since that time have been installed with 1,020-millimeter pipe. The first 1,220-millimeter line pipe was used in 1967 in the construction of the first line of the Tyumen-Moscow system and on the second line of the Central Asia-Moscow trunkline. Construction plans also call for the use of 1,420-millimeter

pipe in the second pipeline of the Tyumen-Moscow system and in the third line of the Central Asia-Moscow network. After 1975 the Tyumen Moscow system will have a capacity of 130 billion cubic meters per year and that of the Central Asia-Moscow network is to reach 110 billion per year. The eventual use of line pipe with diameters of 2 meters (79 inches) and 2.5 meters (98 inches) is under consideration; such pipelines will have capacities of 50 billion and 100 billion cubic meters per year, respectively. The major natural gas pipelines in operation in the U.S.S.R. are listed in Figure 68 and are shown on Figure 77. Pipeline laying operations on the Central Asia-Moscow line are shown in Figure 34.

Soviet natural gas pipelines are designed to operate at pressures of about 780 pounds per square inch, considerably lower than the U.S. average of 1,030 pounds per square inch. Efforts are being made to increase pipeline operating pressures to 925 pounds per square inch but better compressors will have to be developed to reach this goal. In the past, shortages of large diameter pipe and related operating equipment, such as valves, have hindered pipeline construction. For example, undersized valves were used on the Central Asia-Urals network and throughput capacity was reduced 15%. Shortages of large diameter pipe are expected to continue through 1970 and it is expected that at least 700,000 tons of pipe will be imported during 1968-70 from both eastern and western Europe.

Capital investment in the construction of natural gas pipelines in the U.S.S.R. during 1959-65 amounted to 1.5 billion rubles, or about 40% of the total capital investment in the gas industry. Present Soviet construction includes laying 1,220-millimeter natural gas pipelines. Use of large diameter line pipe is claimed to yield significant economies in the requirements for steel. The amount of steel required for pipeline construction is being further reduced by efforts to fabricate pipe with a wall thickness that averages only 1% of the diameter. Even greater economies in steel and investment costs are anticipated from the use of ultra-large (2-2.5 meter) diameter line pipe in the future. Indexes of the capital investment and steel requirements for the larger size U.S.S.R. gas lines are given in Figure 35.

High fixed cost in the transport of gas makes variation in unit cost depend largely on the degree of utilization of pipeline capacity. In recent years unit costs of moving gas from distant producing regions to consuming centers have been reduced as a result of using larger diameter line pipe to increase throughput capacities. For example, the average cost of transporting 10,000 cubic meters of natural gas in the U.S.S.R. declined from about 22 rubles in 1959 to about 17 rubles in 1965 (Figure 36).

(4) *Consumption*

(a) BY COUSUMING SECTOR — Natural gas is finding increased favor in the U.S.S.R. as an industrial and household fuel and is being used to an increasing degree as a raw material in the manufacture of chemicals. Natural gas can be produced and transported more cheaply than other types of fuel, and it has a higher thermal efficiency. Because of these advantages natural gas is being substituted on a growing scale for other types of fuels, particularly coal, at electric powerplants and at enterprises of the metallurgical and construction materials industries. It has been reported that during 1959-65 the delivered cost of natural gas was 7.8 billion rubles less than the cost of supplying the same quantity of energy from alternative sources.

The industrial sector of the Soviet economy consumes more than 80% of the total natural gas used. In this sector, electric powerplants are the major consumer, having accounted for more than 30% of industrial consumption of natural gas and more than one-fourth of total use in 1967. The most significant gains in consumption of gas since 1958 have been register

FIGURE 34. LAYING 40-INCH PIPE FOR CENTRAL ASIA – MOSCOW GAS PIPELINE

FIGURE 35. INDEXES OF CAPITAL INVESTMENT AND STEEL REQUIREMENTS FOR GAS PIPELINES OF VARYING DIAMETERS

INDICATOR	PIPELINE DIAMETER				
	40 in.	48 in.	56 in.	79 in.	98 in.
Throughput capacity	100	160	237	594	1,050
Total capital investment for pipe	100	125	171	382	615
Average capital investment	100	79	72	64	58
Total steel required	100	142	195	400	613
Average steel consumption	100	89	82	67	58

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FIGURE 36. AVERAGE COSTS OF PIPELINE TRANSPORT OF NATURAL GAS

YEAR	TRANSPORT EXPENDITURE	COST 10,000 CUBIC METERS	COST 10,000 CUBIC METERS FOR 100 KILOMETERS
	Million rubles	*Rubles*	*Rubles*
1959	40.5	22.3	3.91
1960	50.5	22.1	3.64
1961	77.7	20.7	3.34
1962	98.6	19.4	3.08
1963	112.8	16.0	2.46
1964	139.8	16.0	2.45
1965	174.1	16.9	2.45

by the metallurgical and chemical industries. The share of total consumption by the chemical industry rose from about 1% in 1958 to almost 6% in 1967 while that of metallurgy increased from 6% to 17% during the same period. Efforts also have been made to increase the supply of gas to households. Consumption of gas by the commercial-household sector during 1959-67 rose five-fold but the relative share of total consumption increased only from about 10% to 11%. Data on consumption of natural gas in the U.S.S.R. by consuming sector is given in Figure 69.

Preliminary plans for 1970 (the lowered goal for production will cause a downward revision of the estimates of consumption) called for consumption of gas by industry to reach about 175 billion cubic meters including 55 billion for electric powerplants, 44 billion for metallurgy, 15 billion for chemicals. The commercial-household sector is expected to consume at least 32 billion cubic meters, about 80% more than in 1965.

(b) BY ECONOMIC REGION — The regional pattern of consumption of natural gas in 1958 was for the most part determined by use in the cities of Moscow, L'vov, Kiev, Kharkov, and Baku. In that year almost two-thirds of the total available natural gas was consumed in Regions III, V, and VII where these cities are located. By 1965 with the completion of several large diameter pipelines into the Moscow area and into the Urals region, Regions VII and VIII increased their share of total gas consumption to about 32%, compared to almost 22% in 1958. Details on regional consumption of natural gas in the U.S.S.R. are given in Figure 70.

(5) *Foreign trade* — Prior to 1967 the U.S.S.R. exported small quantities of natural gas to Poland via pipeline and did not import any natural gas. The quantities exported during 1958-66 were as follows, in millions of cubic meters:

1958	1959	1960	1961	1962
206	222	242	272	300
1963	**1964**	**1965**	**1966**	**1967**
301	295	392	828	1,290

In 1967 the U.S.S.R. began to export natural gas through the new pipeline ("Brotherhood") from the Dolina fields in the Ukraine S.S.R. to Sala in Czechoslovakia. Total Soviet exports of natural gas in 1967 reached about 1.3 billion cubic meters, of which about 1 billion went to Poland and the remainder to Czechoslovakia. By 1970 exports to these 2 countries may reach 2.5 to 3 billion cubic meters. The Soviet Union began exports of small volumes of liquefied petroleum gases (LPG) in 1967 to France from new facilities at Riga on the Baltic coast. Also, during 1967 the U.S.S.R. began for the first time to import natural gas from Afghanistan via a newly completed pipeline network. Such imports probably did not exceed 300 million cubic meters in 1967 but are to increase gradually to 2 billion cubic meters in 1970, 3.5 billion in 1973, and 4 billion annually during 1976-84. By 1970 imports of natural gas from Iran are scheduled to reach 6 billion cubic meters per year if the 42-inch pipeline from Iran to the U.S.S.R. now under construction can be completed on schedule. Deliveries from Iran will increase to 10 billion cubic meters by 1974 and are to remain at that level until 1985. The imported gas will be used to augment local supplies in Central Asia and in the Transcaucasus region.

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The U.S.S.R. has been conducting negotiations with Free World nations—Austria, Italy, Japan, France, Finland, Sweden—to export natural gas. In mid-1968 a contract was signed with Austria to supply Soviet natural gas for 23 years, beginning with 300 million cubic meters in 1968 and reaching 1 billion cubic meters per year in 1970 and a maximum of 1.5 billion by 1975. No further contracts with other Free World countries have been made as some of these countries are reluctant to become dependent on Soviet supplies over the long term in view of the prolific alternative sources of natural gas being developed in the North Sea, the Netherlands, Algeria, Libya, and in offshore areas of the Mediterranean and Adriatic Seas.

(6) *Storage* — Optimum utilization of natural gas transmission and processing facilities depends on a regular flow of gas at, or near, the maximum possible level of throughput. Demand for natural gas fluctuates on a seasonal basis with maximum rates being experienced in the winter months and slack demand periods occurring in the summer. Such fluctuations may cause daily gas consumption rates at large Soviet industrial centers to vary 50% above or below the average daily requirements. Soviet pipeline operating procedures are being adapted to each situation. The most practical solutions to problems of over supply and under supply in the U.S.S.R. have been: the interconnection of pipeline systems as with the "Moscow Gas Ring," which permits shifting of supply; construction of multiline pipeline systems; development of buffer consumers such as electric powerplants (Soviet powerplants switch to gas 6 or 7 months a year during slack demand periods and to other fuels in peak demand seasons); and the construction of underground gas storage reservoirs.

Storage of surplus gas during the summer months, primarily near centers of consumption, permits a given

system to meet excessive requirements for gas during the winter when heating needs often cause total demand for gas to exceed the total capacity of the transmission system. Underground storage caverns fall into four categories: water-free sandstone reservoirs, such as in depleted oil and gas fields; water-bearing strata that usually overlie and conform to dome shaped structures; natural underground caverns; and artificial, or manmade caverns such as dissolved (leached out) salt domes and mined out rock caverns.

In 1963 a program was announced calling for the construction of 27 underground natural gas storage reservoirs near large Soviet industrial centers by 1970. At least 12 areas have been surveyed for gas storage in the European portion of the U.S.S.R. Total gas storage capacity is expected to reach 17-18 billion cubic meters with an active withdrawal capacity of about 9-11 billion cubic meters by 1970. Present withdrawal capacity in the U.S.S.R. is estimated at 5-6 billion cubic meters. The Soviets have made unique technological headway in utilizing shallow gently dipping aquifers for natural gas storage near Moscow, Leningrad, and elsewhere. Total storage capacity of reservoirs located in water-bearing strata is estimated at 10 billion cubic meters with an active withdrawal capacity of about 5 billion cubic meters of gas. During the winter of 1966-67, only 3.4 billion cubic meters were stored in underground facilities and a total of 1.4 billion cubic meters were withdrawn. A list of the underground storage reservoirs, by type, and capacity of each is given in Figure 71.

In addition to underground caverns, spherical pressure tanks also are used for storing small volumes of gas on the surface, for industrial consumers and for LPG distribution systems.

b. Natural gas liquids — In contrast with the United States, where the production of natural gas liquids reached about 51 million tons in 1967, the production of natural gas liquids in the U.S.S.R. had not been stressed. Only with the establishment of a petrochemicals industry and the desire to supply gas to rural regions has emphasis been placed on increasing production of natural gas liquids. Data are not available on total production of natural gas liquids during the post war years. However, according to the control figures of the Seven Year Plan, output was to rise from 550,000 tons in 1959 to 6.5 million tons in 1965.

As has been the case in the United States, the planned increase in production of natural gas liquids was to be derived largely from increased yields of liquefied petroleum gases (LPG). The original goal for 1965 called for the output of 4.4 million tons of LPG, but actual output was only about 2.8 million tons. The shortfall resulted from shortages of consuming equipment, transport, and storage facilities; lack of facilities for collection of associated gas and for stabilization of crude oil; and failure to meet schedules for construction of natural gasoline plants. The estimated output of LPG in the U.S.S.R. during 1958-65 and 1967 follows, in thousand of tons:

1958	308
1959	503
1960	660
1961	950
1962	1,256
1963	1,661
1964	2,299
1965	2,793*
1967	3,612

*More than three-fourths of total output came from Urals-Volga regions.

Although the original plan for 1965 was not achieved, actual output of LPG rose eightfold during the Seven Year Plan period. Ten new natural gasoline plants were put into operation during 1959-65, raising the capacity of gas processing units sixfold over that in 1958. Plans for 1970 call for increasing the capacities of some existing plants and for construction of at least 8 new natural gasoline plants. A list of the natural gasoline plants in operation, under construction, and planned is given in Figure 72. Typical LPG storage facilities are shown in Figure 37.

Although some use is made of LPG as a motor fuel (less than 6% of total output in 1965), it is consumed principally as a raw material for the manufacture of chemicals and as a household fuel. In 1965, 63% of the total available LPG was used by the chemical industry, about 26% by the commercial-household sector, and the remainder by other industrial and trans-

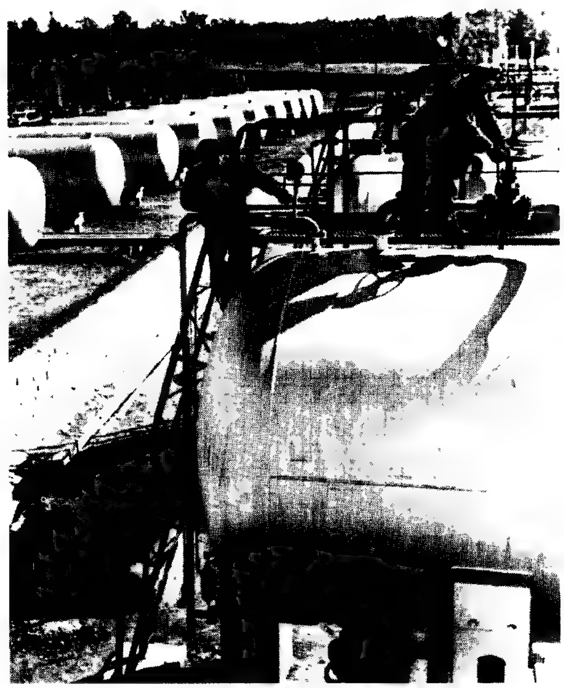

Figure 37. Liquefied petroleum gas (LPG) storage facilities near Tatar oilfield in Urals-Volga region

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port sectors. At the end of 1965 about 4 million apartments were reported to be using LPG. The estimated consumption of LPG in the U.S.S.R., by economic region, in 1965 is as follows, in thousands of tons:

IV North Caucasus	161
VI Volga	1,305
VIII Urals	116
IX West Siberia	135
All other	513
Total R.S.F.S.R.	2,230
II Baltic and Belorussia	72
III South	116
V Transcaucasus	215
X Kazakh S.S.R. and Central Asia	160
Total U.S.S.R.	2,793

The changing pattern of consumption of LPG by consuming sector, during 1958-65 is shown in Figure 73.

Rail and pipeline are used primarily for the transport of LPG from producing to consuming areas. At the end of 1965 about 3,500 propane-butane rail tank cars reportedly were in service, delivering about two-thirds of the LPG consumed in the U.S.S.R.

D. Statistical data

This subsection consists of detailed statistical data in tabular form in general order of reference in text. 25X1

FIGURE 38. COAL RESERVES,
(*Billions*

ECONOMIC REGION	BASIN, DEPOSIT OR LOCATION OF DEPOSITS	TOTAL	CATEGOTY OF RESERVES		
			Actual	Probable	Possible
	Western regions				
Ib	North				
	Pechora basin	344.50	4.10	19.40	321.00
III	Ukrainian S.S.R.				
	L'vov-Volyn' region	1.75	1.65	0.10	0
	Dneper basin	4.18	3.05	0.99	0.14
	Donets basin	173.16	49.00	56.49	67.67
	Total III	179.09	53.70	57.58	67.81
IV	Northern Caucasus				
	Donets basin	67.46	8.16	23.04	36.26
	Deposits on the northern slopes of the Caucasus	1.32	0.10	0.25	0.97
	Total IV	68.78	8.26	23.29	37.23
V	Transcaucasus				
	Tkibuli deposit	0.46	0.29	0.17	0
	Tkvarcheli deposit	0.08	0.07	0.01	0
	Akhaltsikhe deposit	0.15	0.10	0	0.05
	Total V	0.69	0.46	0.18	0.05
VI	Volga				
	Kama basin	30.32	0	0	30.32
VII	Central				
	Moscow basin	24.31	8.89	5.32	10.10
na	Other deposits	1.60	0.06	0.29	1.25
	Eastern regions				
VIII	Urals				
	Kizel basin	1.06	0.61	0.32	0.13
	Yuzhno-Ural basin	1.76	1.56	0.20	0
	Chelyabinsk basin	1.63	1.37	0.19	0.07
	Orsk basin	1.03	0.62	0.41	0
	Northern Sos'va coal-bearing region	1.07	0.21	0.29	0.57
	Other deposits	0.96	0.63	0.15	0.18
	Total VIII	7.51	5.00	1.56	0.95
IX	Western Siberia				
	Kuznetsk basin	905.30	70.88	253.51	580.91
	Gorlovo basin	17.23	0.07	2.26	14.90
	Deposits of Tomskaya Oblast'	2.59	0	0	2.59
	Other deposits	0.11	0	0	0.11
	Total IX	925.23	70.95	255.77	598.51

Footnotes are at end of table.

U.S.S.R., 1957
of tons)

Reserves according to depth from surface				Reserves by type of coal*					
0 300 m.	300 to 600 m.	600 to 1,200 m.	1,200 to 1,800 m.	A and T	PS, K and PZh	G	D	DB	B
57.00	81.10	115.90	90.50	30.80	117.00	103.20	93.50	0	0
0.06	1.55	0.14	0	0	0.01	1.74	0	0	0
4.18	0	0	0	0	0	0	0	0	4.18
20.90	35.53	71.05	45.68	39.78	28.63	63.57	19.75	21.43	0
25.14	37.08	71.19	45.68	39.78	28.64	65.31	19.75	21.43	4.18
7.49	14.52	25.36	20.09	53.70	3.45	1.86	8.45	0	0
0.42	0.90	0	0	0.01	0.04	1.27	0	0	0
7.91	15.42	25.36	20.09	53.71	3.49	3.13	8.45	0	0
0.24	0.17	0.05	0	0	0	0.46	0	0	0
0.08	0	0	0	0	0.08	0	0	0	0
0.04	0.07	0.04	0	0	0	0	0	0	0.15
0.36	0.24	0.09	0	0	0.08	0.46	0	0	0.15
0	0	24.64	5.68	0	0	0	0	30.32	0
24.31	0	0	0	0	0	0	0	0	24.31
1.50	0.10	0	0	0	0	0	0	0	1.60
0.32	0.20	0.43	0.11	0	1.06	0	0	0	0
1.76	0	0	0	0	0	0	0	0	1.76
1.04	0.45	0.13	0.01	0	0	0	0	0	1.63
1.03	0	0	0	0	0	0	0	0	1.03
1.07	0	0	0	0	0	0	0	0	1.07
0.73	0.17	0.06	0	0.31	0	0.23	0	0	0.42
5.95	0.82	0.62	0.12	0.31	1.06	0.23	0	0	5.91
156.48	169.34	302.36	277.12	263.42	216.00	304.82	65.16	55.90	0
3.30	3.80	6.53	3.60	17.23	0	0	0	0	0
2.59	0	0	0	0	0	0	0	0	2.59
0.11	0	0	0	0	0	0	0	0	0.11
162.48	173.14	308.89	280.72	280.65	216.00	304.82	65.16	55.90	2.70

FIGURE 38. COAL RESERVES,

ECONOMIC REGION	BASIN, DEPOSIT OR LOCATION OF DEPOSITS	TOTAL	CATEGOTY OF RESERVES		
			Actual	Probable	Possible
	Eastern regions (*Continued*)				
Xa... ...	Kazakhstan				
	Karaganda basin	51.23	10.30	25.76	15.17
	Turgan (Ubagan) basin	36.49	6.32	10.53	19.64
	Ekibastuz deposit	12.21	9.11	1.30	1.80
	Maykuben deposit	21.01	1.33	13.11	6.57
	Lenger deposit	2.02	0.12	0.20	1.70
	Other deposits	16.94	1.81	6.33	8.80
	Total Xa	**139.90	28.99	57.23	53.68
Xb...	Central Asia				
	Gissar coal-bearing region	3.78	0.06	0.11	3.61
	South Gissar coal-bearing region	1.67	0.01	0.01	1.65
	South Tadzhik depression	2.46	0	0	2.46
	Ziddy deposit	1.44	0.02	0.07	1.35
	Magian deposit	1.07	0.01	0.04	1.02
	Fan-Yagnob deposit	1.78	0.34	0.37	1.07
	Other deposits of Zeravshan region	1.93	0	0	1.93
	Nazar-Aylok deposit	0.44	0	0.02	0.42
	Shuroabad-Ravnouss deposit	0.68	0.02	0.04	0.62
	Mionadus deposit	1.47	0	0.03	1.44
	Sulyukta deposit	0.76	0.17	0.16	0.43
	Angren deposit	2.82	1.52	0.40	0.90
	Pritashkentskiy region	0.64	0	0	0.64
	Shurab deposit	3.08	0.13	1.14	1.81
	Kyzyl-Kiya deposit	2.38	0.11	0.17	2.10
	Deposits of northern Fergana	2.55	0.15	0.47	1.93
	Aldyyar deposit	0.48	0.02	0.13	0.33
	Kok-Yangak deposit	2.07	0.22	0.08	1.77
	Eastern Fergana (Uzgen) basin	3.09	0.27	1.66	1.16
	Minkush coal-bearing region	4.21	0.47	0.70	3.04
	Other deposits	1.98	0.03	0.26	1.69
	Total Xb	40.78	3.55	**5.62	**31.61
XI...	Eastern Siberia				
	Kansk Achinsk basin	1,220.30	35.00	234.28	951.02
	Minusinsk basin	36.94	2.31	32.98	1.65
	Deposits of Tuvinskaya	18.68	1.06	2.20	15.42
	Irkutsk basin	88.90	5.17	29.54	54.19
	Taymyr basin	583.50	0.25	23.25	560.00
	Tungus basin	1,744.77	1.40	53.37	1,690.00
	Ust'-Yenisey coal-bearing region	221.75	0	4.75	217.00
	Lena basin	2,647.24	1.79	106.87	2,538.58
	Yuzhno-Yakutsk coal-bearing area	40.05	0.65	2.40	37.00
	Zyryanka coal-bearing area	102.60	0.34	2.26	100.00
	Deposits of Transbaykal	8.37	1.63	1.43	5.31
	Other deposits	0.56	0.02	0.01	0.53
	Total XI	6,713.66	49.62	493.34	6,170.70

Footnotes are at end of table.

(*Continued*)

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RESERVES ACCORDING TO DEPTH FROM SURFACE				RESERVES BY TYPE OF COAL*					
0–300 m.	300 to 600 m.	600 to 1,200 m.	1,200 to 1,800 m.	A and T	PS, K and PZh	G	D	DB	B
9.74	9.04	19.64	12.82	0	49.43	0.63	0	0	1.17
29.83	6.66	0	0	0	0	0	0	0	36.49
4.62	5.84	1.75	0	0	12.16	0.05	0	0	0
14.02	6.36	0.63	0	0	0	0	0	0	21.01
0.08	0.35	1.11	0.48	0	0	0	0	0	2.02
10.75	2.29	3.00	0.90	1.83	11.10	1.50	0.04	0	2.47
69.04	30.54	26.13	14.20	1.83	72.69	2.18	0.04	0	63.16
0.33	0.72	1.37	1.36	0.45	3.27	0.06	0	0	0
0.34	0.35	0.70	0.28	0	1.67	0	0	0	0
0	0	1.23	1.23	0	2.46	0	0	0	0
1.44	0	0	0	0	1.44	0	0	0	0
0.15	0.13	0.31	0.48	0	0	0	1.07	0	0
0.75	0.32	0.48	0.23	0	0.98	0.80	0	0	0
0.72	1.15	0.06	0	0	0	1.93	0	0	0
0.28	0.11	0.05	0	0.44	0	0	0	0	0
0.12	0.14	0.17	0.25	0	0.68	0	0	0	0
0.24	0.25	0.48	0.50	0.67	0.80	0	0	0	0
0.11	0.23	0.22	0.20	0	0	0	0	0	0.76
0.95	0.98	0.73	0.16	0	0	0	0	0	2.82
0	0	0.28	0.36	0	0	0	0	0	0.64
0.39	0.71	1.24	0.74	0	0	0	0	0	3.08
0.07	0.55	1.21	0.55	0	0	0	0	0	2.38
0.57	0.65	0.75	0.57	0	0	0	2.55	0	0
0.12	0.07	0.11	0.18	0	0	0.48	0	0	0
0.57	0.68	0.53	0.29	0	0	0	2.07	0	0
1.17	0.67	0.85	0.40	1.03	1.02	1.04	0	0	0
1.01	0.92	1.27	1.01	0	0	0	0	0	4.21
0.25	0.55	0.79	0.39	0.35	0.45	0.33	0.56	0	0.29
9.58	9.18	12.83	9.18	2.94	12.77	4.64	6.25	0	14.18
249.90	114.70	487.30	368.40	0	0	1.70	0.06	0	1,218.54
17.50	8.50	9.29	1.65	0	0	7.51	29.43	0	0
3.25	3.75	4.94	6.74	0	7.27	11.41	0	0	0
87.17	1.73	0	0	0	0	36.20	48.50	0	4.20
83.30	104.30	242.90	153.00	143.10	412.30	0	0	0	28.10
575.00	485.77	646.00	38.00	522.00	737.00	52.00	243.00	190.77	0
51.50	63.40	67.85	39.00	0	0	0	55.00	166.75	0
779.09	560.25	713.50	594.40	1.49	***390.50	0	749.80	0	1,505.45
24.95	15.10	0	0	0	39.60	0.45	0	0	0
34.30	24.40	31.30	12.60	0	102.60	0	0	0	0
6.72	1.53	0.12	0	0	0	***1.18	0	3.80	3.39
0.56	0	0	0	0	0	0	0	0	0.56
1,913.24	1,383.43	2,203.20	1,213.79	666.59	1,494.02	305.11	1,126.38	361.32	2,760.24

FIGURE 38. COAL RESERVES,

ECONOMIC REGION	BASIN, DEPOSIT OR LOCATION OF DEPOSITS	TOTAL	CATEGOTY OF RESERVES		
			Actual	Probable	Possible
	Eastern regions (*Continued*)				
XII	Far East				
	Bureya basin	25.02	1.08	9.24	14.70
	Bikin deposit	2.90	1.43	0.51	0.96
	Suy'fun basin	1.66	0.37	0.15	1.14
	Suchan basin	1.43	0.19	0.34	0.90
	Uglovaya basin	1.02	0.65	0.26	0.11
	Maykhin deposit	0.60	0.32	0.28	0
	Suputin deposit	0.45	0.10	0.35	0
	Deposits on Sakhalin	20.09	2.01	3.88	14.20
	Otsukchan coal-bearing area	2.87	0.01	0.03	2.83
	Otolon coal-bearing area	0.55	0	0	0.55
	Chaun-Chukot coal-bearing area	1.30	0	0	1.30
	Anadry coal-bearing area	97.71	0.01	0	97.70
	El'gen deposit	2.93	0.03	0.50	2.40
	Avekov deposit	13.91	0.01	0	13.90
	Okhotsk coal-bearing area	10.00	0.20	3.30	6.50
	Arkagala coal bearing area	1.09	0.15	0.01	0.93
	Bukhta Ugol'naya	6.18	0.07	2.38	3.73
	Deposits on Kamchatka Peninsula	0.83	0.03	0.80	0
	Other deposits	2.60	0.96	0.28	1.36
	Total XII	193.14	7.62	22.31	163.21
	Total Western regions	649.29	75.47	105.06	467.76
	Total Eastern regions	8,020.22	165.73	835.83	7,018.66
Total U.S.S.R.		8,669.51	241.20	941.89	7,486.42

na Data not available.

*A —anthracite; T—lean or low-volatile bituminous; PS—steam-caking (bit.); K—coking (bit.); PZh—steam-fat (bit.); G—gas (bit.); D—long-flame (bit.); DB—sub-bituminous coals; B—brown coal or lignite.

**As reported. The total is not equal to the sum of the components.

***Information adequate to permit accurate allocation of these quantities between the category, PS, K, and PZh, and the category, G, was not available. In the sub-totals, these quantities were arbitrarily allocated equally to each category.

(*Continued*)

RESERVES ACCORDING TO DEPTH FROM SURFACE				RESERVES BY TYPE OF COAL*					
0 300 m.	300 to 600 m.	600 to 1,200 m.	1,200 to 1,800 m.	A and T	PS, K and PZh	G	D	DB	B
6.19	7.20	7.63	4.00	0.02	0	25.00	0	0	0
2.71	0.19	0	0	0	0	0	0	0	2.90
0.75	0.85	0.06	0	0	0.03	0	1.63	0	0
0.29	0.24	0.59	0.31	0.34	0.32	0.66	0.11	0	0
0.51	0.38	0.13	0	0	0	0	0	0.11	0.91
0.50	0.10	0	0	0	0	0	0	0	0.60
0.35	0.10	0	0	0	0	0	0	0	0.45
10.38	5.33	2.88	1.50	0.05	1.80	0.85	7.08	4.94	5.37
0.89	0.79	1.07	0.12	2.87	0	0	0	0	0
0.52	0.03	0	0	0	0	0.55	0	0	0
0.10	0.20	0.60	0.40	0	1.30	0	0	0	0
24.51	24.10	35.40	13.70	0	0	0	0	0	97.71
2.93	0	0	0	0	0	0	0	0	2.93
6.96	6.95	0	0	0	0	0	0	0	13.91
10.00	0	0	0	0	0	0	0	0	10.00
0.88	0.21	0	0	0	0	0	1.09	0	0
3.48	1.80	0.80	0.10	0	***6.18	0	0	0	0
0.83	0	0	0	0	0	0.20	0.63	0	0
2.22	0.36	0.02	0	0.56	0.10	0.24	0	0	1.70
75.00	48.83	49.18	20.13	3.84	6.64	30.59	10.54	5.05	136.48
116.22	133.94	237.18	161.95	124.29	149.21	172.10	121.70	51.75	30.24
2,235.29	1,645.94	2,600.85	1,538.14	956.16	1,803.18	647.57	1,208.37	422.27	2,982.67
2,351.51	1,779.88	2,838.03	1,700.09	1,080.45	1,952.39	819.67	1,330.07	474.02	3,012.91

FIGURE 39. PRODUCTION OF COAL BY REGIONS AND BASINS

25X1

(*Millions of tons*)

	1958	1960	1961	1965	1966
Western (European) regions:					
Pechora Basin	16.8	17.6	17.6	17.3	18.8
Donets Basin	181.7	188.2	186.1	205.9	207.4
Moscow Basin	47.3	42.8	36.8	40.8	39.2
Dnieper Basin	*na*	*na*	*na*	*na*	11.0
L'vov-Volyn' Basin	2.0	*na*	*na*	8.9	10.0
Georgian S.S.R.	3.0	2.9	2.7	2.6	2.6
Other*	13.7	16.2	17.6	13.6	1.9
Subtotal	264.5	267.7	260.8	289.1	290.9
Urals region	58.1	59.0	59.3	61.6	57.8
Subtotal	58.1	59.0	59.3	61.6	57.8
Eastern regions:					
Kazakh S.S.R.	31.5	32.4	34.6	45.8	48.2
Including Ekibastuz deposit	6.2	6.0	7.4	14.6	15.5
Karaganda Basin	24.4	25.8	26.7	30.9	32.0
Kuznetsk Basin	75.4	84.0	84.9	96.9	100.2
Kirgiz S.S.R.	3.4	3.5	3.4	3.7	3.9
Tadzhik S.S.R.	0.8	0.9	0.8	0.9	0.9
Uzbek S.S.R	3.5	3.4	4.4	4.5	3.9
Far East region	20.0	21.9	21.7	27.3	**29.6
Other*	36.0	36.8	36.5	47.9	50.2
Subtotal	170.6	182.9	186.3	227.0	236.9
Total, U.S.S.R.	493.2	509.6	506.4	577.7	585.6

na Data not available.

*Residual includes other producers.

**Estimated.

FIGURE 40. PRODUCTION OF COAL BY TYPE (U/OU)

(*Thousands of tons*)

	1958	1960	1962	1963	1964	1965	1966	1967
Total coal	493,236	509,623	517,408	531,722	553,997	577,731	585,604	595,201
Including:								
Anthracite	*74,220	74,128	72,536	72,729	74,898	76,467	76,775	77,139
Bituminous	278,810	300,797	313,896	322,403	333,972	351,414	362,395	374,247
Of which,								
Coking coal	94,407	110,198	117,462	127,063	133,617	138,959	142,549	147,623
Subtotal, hard coal**	353,030	374,925	386,432	395,132	408,870	427,881	439,170	451,386
Brown coal	140,206	134,698	130,976	136,590	145,127	149,850	146,434	143,815
Strip-mined coal***	97,940	101,977	114,280	121,254	130,854	140,517	146,035	151,164
Percentage of total coal strip-mined	*19.9*	*20.0*	*22.1*	*22.8*	*23.6*	*24.3*	*24.9*	*25.4*

*Estimated.

**Includes anthracite and bituminous coal.

***Includes both hard coal and brown coal.

FIGURE 41. PRODUCTION OF COKING COAL,* BY BASINS

25X1

(*Millions of tons*)

	1958	1959	1960	1961	1962	1963	1964	1965
Pechora	2.5	3.2	3.8	3.9	4.0	4.4	4.8	4.7
Donets	54.5	58.9	64.9	65.6	68.3	74.8	77.4	80.8
Kuznetsk	25.7	26.9	28.5	30.2	32.6	33.9	36.7	37.5
Karaganda	6.6	7.1	8.2	8.2	8.2	9.5	9.8	11.0
Urals	2.2	2.1	2.3	2.2	**2.1	**2.2	*na*	*na*
Georgian deposits	2.4	2.3	2.2	2.1	2.3	2.3	2.1	2.0
East Siberian deposits	0.4	0.4	0.2	0.1	*Insig*	*Insig*	*na*	*na*
U.S.S.R. total***	94.4	100.8	110.2	112.4	117.5	127.1	133.6	139.0

na Data not available.

*As mined and before cleaning.

**Estimated.

***As reported. The total may not be equal to the sum of the components.

FIGURE 42. CLASSIFICATION AND CHARACTERISTICS OF SOVIET COALS

SYMBOL AND TYPE	DESIGNATION	PERCENT VOLATILE MATTER		CAKING PROPERTIES	AVERAGE ANALYSIS,* DONETS COALS			
		Donets	Kuznetsk		Percent moisture	Percent ash	Percent sulfur	Calorific value
								Kilocals/kg.
A (antrasit)	Anthracite	<6	....	No caking properties	5.5	17.0	2.0	6,230
PA (polu-antrasit)	Semianthracite	6-9	6-8	No caking properties	5.5	17.0	2.2	6,400
T (toshchiy)	Lean (bituminous)	9-17	<17	No caking properties	5.0	18.5	2.9	6,380
PS (parovichno-spekayushchiysya)	Steam caking (bit.)	12-18	....	Medium caking	na	na	na	na
OS (otoshchennyy-spekayushchiysya)	Poorly caking (bit.)	14-22	....	Faint to weakly caking	4.5	19.5	2.5	6,340
SS (slabo-spekayushchiysya)	Weakly caking (bit.)	....	12-42	Faint to weakly caking				
SP (spekayushchiysya-parovichno)	Caking steam (bit.)	....	na	Moderately caking	....	....	....	....
K (koksovyy)	Coking (bit.)	18-27	17-38	Highly caking	5.0	19.0	3.0	6,280
PZh (parovichno-zhirnyy)	Fat steam (bit.)	27-35	....	Highly caking	na	na	na	na
Zh (zhirnyy)	Fat (bituminous)	26-36	24-42	Highly caking	5.0	19.5	3.0	6,140
G (gazovyy)	Gas (bituminous)	36-44	38-44	Slightly caking	7.0	18.0	3.7	5,830
D (dlinno-plamennyy)	Long-flame (bit.)	37-42	42-48	Non-caking	13.0	17.5	4.5	5,180
B (buryy)	Brown coal	....	>42	Non-caking	....	....	....	....

na Data not available.

*As received basis.

FIGURE 43. SIZE CLASSIFICATION OF SOVIET COALS

(Screen size in millimeters)

TYPE OF COAL	DESIGNATION AND SIZE							
	Run of mine	Lump	Lump	Large	Nut	Small	Slack	Fines
Anthracite	Ryadovoi (unscreened)	Plitny >100	Kulak 100 x 50	...	Oryekh 50 x 25	Melkii 25 x 13	Semechko 13 x 6	Shtyb. 6 x 0
Bituminous*	Ryadovoi (unscreened)	...	...	Krupny 100 x 50	Oryekh 50 x 25	Melkii 25 x 13	Semechko 13 x 6	Shtyb. 6 x 0
Brown**	Ryadovoi (unscreened)	..	...	Krupny 100 x 50	Oryekh 50 x 25	...	...	Melkii. 25 x 0

*Not as standardized as anthracite, sizes vary widely between mining districts.

**Moscow basin only.

25X1

FIGURE 44. MECHANIZED COAL PREPARATION* IN THE U.S.S.R.

(*Millions of tons*)

	1958	1960	1962	1963	1964	1965	1966**	1967**
Total raw coal cleaned	124.9	152.1	169.8	181.7	198.0	215.0	221.2	236.1
Including at mine plants	97.1	116.8	132.2	141.9	158.0	174.9	181.0	195.7
Including at coke-chemical plants	27.8	35.3	37.6	39.8	40.0	40.1	40.2	40.4
Total raw coking coal cleaned	85.7	98.5	111.0	118.8	125.0	129.9	131.0	131.0
Including at mine plants	57.9	63.2	73.4	79.0	85.0	89.8	90.8	90.6
Including at coke-chemical plants	27.8	35.3	37.6	39.8	40.0	40.1	40.2	40.4
Total cleaned coal produced	79.3	95.1	105.6	113.1	119.6	129.4	135.3	143.0
Including at mine plants	57.7	67.8	77.0	83.1	89.2	98.7	104.5	112.0
Of which, coking coal	39.2	42.8	49.8	53.1	58.1	60.8	61.7	63.5
Including at coke-chemical plants	21.6	27.3	28.6	30.0	30.4	30.7	30.8	31.0
Total cleaned coking coal produced	60.8	70.0	78.5	83.1	88.5	91.5	92.5	94.5
Total cleaned non-coking coal produced	18.5	25.1	27.1	30.0	31.1	37.9	42.8	48.5

NOTE—Figures may not add to totals because of rounding.

*Excluding hand-picking and mechanized screening at the mine.

**Preliminary estimate.

25X1

FIGURE 45. EXPORTS OF COAL*

(*Thousands of tons*)

DESTINATION	1958	1960	1962	1963	1964	1965	1966	1967
Free World Countries:								
Austria	292	733	838	905	900	819	841	745
Algeria	0	0	0	0	5	5	0	0
Belgium	69	20	181	600	485	290	270	261
Denmark	16	413	469	672	660	522	621	500
Finland	789	739	731	621	762	665	545	460
France	703	795	949	1,908	1,723	1,601	1,465	1,497
Greece	24	51	30	42	37	40	52	39
Iceland	1	1	1	1	1	1	0	1
Italy	258	475	1,021	1,194	1,213	1,023	1,360	1,845
Japan	437	542	1,144	956	1,088	1,233	1,589	2,379
Netherlands	41	32	120	294	252	92	29	23
Sweden	67	141	114	246	300	428	203	330
Switzerland	0	0	0	0	1	2	1	0
Tunisia	0	21	15	20	24	21	22	25
U.A.R. (Egypt)	4	24	0	15	352	421	305	471
West Germany	127	66	227	209	130	58	17	22
Other**	50	14	8	12	75	3	3	0
Total, Free World Countries	2,878	4,067	5,848	7,695	8,008	7,224	7,323	8,598
Communist Countries:								
Bulgaria	0	10	932	1,283	1,994	2,504	3,047	3,231
Cuba	0	7	0	11	0	0	30	88
Czechoslovakia	1,010	1,054	2,862	3,058	3,342	2,915	2,062	2,343
East Germany***	4,778	5,066	6,785	5,838	6,194	5,994	5,876	5,063
Hungary	90	204	298	971	1,318	1,060	876	406
Poland	390	794	1,042	1,228	1,223	1,218	1,164	1,143
Rumania	3	133	395	190	201	251	358	399
Mongolia	77	53	180	31	256	134	9	4
Yugoslavia	725	927	1,008	1,057	1,092	1,123	1,083	1,022
Total, Communist Countries	7,073	8,248	13,502	13,667	15,620	15,199	14,505	†13,714
Total U.S.S.R.	9,951	12,315	19,350	21,362	23,628	22,423	21,828	22,312

*Including small amounts of hard coal briquettes.

**Residual, including bunkers.

***Reported as exports in Soviet trade statistics. Except for small amounts of anthracite coal, however, most of this total was shipped from Poland on the Soviet account.

†Including 15,000 tons to North Korea.

FIGURE 46. IMPORTS OF COAL AND COKE [redacted]

(*Thousands of tons*)

ORIGIN	1958	1960	1962	1963	1964	1965	1966	1967
Coal:								
Poland*	3,559	4,519	4,686	4,829	4,805	6,518	7,206	7,770
Communist China	208	200	201	205	202	201	0	0
Hungary**	49	56	49	75	75	74	55	*na*
Total	†3,826	4,775	4,936	5,109	5,082	6,793	7,261	7,770
High-temperature coke:								
Poland***	678	658	607	654	661	662	654	685
Total	678	658	607	654	661	662	654	685

na Data not available.

*Hard coal, most of which was shipped directly to East Germany on the Soviet account.

**Brown coal and brown coal briquettes.

***Most of this coke was shipped directly to East Germany on the Soviet account.

†Including 10,000 tons of unknown origin.

FIGURE 47. EXPORTS OF COKE [redacted]

(*Thousands of tons*)

DESTINATION	1958	1960	1962	1963	1964	1956	1966	1967†
Free World Countries:								
Austria	30	64	53	79	82	88	92	71
Denmark	80	76	194	257	246	284	292	144
Finland	174	99	207	252	504	517	596	610
Greece	6	9	6	8	11	8	6	6
Iceland	1	1	1	1	0	0	1	1
Sweden	98	125	151	204	101	89	147	58
U.A.R. (Egypt)	4	28	167	18	0	0	0	0
Other*	2	5	4	0	0	1	1	12
Total, Free World Countries	393	407	783	819	944	987	1,135	902
Communist Countries:								
Bulgaria	89	103	106	139	177	103	158	195
Cuba	0	5	24	28	31	31	26	39
Czechoslovakia	0	3	25	32	68	7	5	67
East Germany**	914	1,026	1,378	1,511	1,530	1,505	1,487	1,275
Hungary	617	594	523	636	638	576	604	592
Mongolia	0	0	1	2	1	2	1	1
Rumania	402	407	431	618	599	541	592	551
Yugoslavia	0	101	51	11	11	0	0	0
Total, Communist Countries	***2,024	2,239	2,539	2,977	3,055	2,765	2,873	2,792
Total, U.S.S.R.	2,417	2,646	3,322	3,796	3,999	3,752	4,008	3,694

*Bunkers and unaccounted destination.

**Much of the coke ostensibly shipped to East Germany from the U.S.S.R. actually originated in Poland, but was credited to the Soviet account.

***Including 2,000 tons to Albania.

†Preliminary report.

FIGURE 48. INVESTMENT IN GEOPHYSICAL SURVEYING AND EVALUATION OF EXPLORATORY OIL WELLS 25X1
(*Millions of rubles*)

YEAR	U.S.S.R. TOTAL	R.S.F.S.R.	AZERBAYDZHAN	UKRAINE	UZBEK	KAZAKHSTAN	TURKMEN	OTHER
1959	32.46	21.10	3.80	2.20	1.64	1.42	1.53	0.77
1960	36.19	23.30	4.10	2.78	1.98	1.57	1.59	0.87
1961	40.87	25.70	4.12	3.52	2.75	1.86	1.61	1.31
1962	46.62	28.44	4.88	4.84	2.62	2.03	2.15	1.66
1963	48.57	30.96	4.40	4.16	2.70	2.06	2.46	1.83
1964	55.11	33.40	5.70	4.71	3.98	3.02	2.83	1.47
1965	59.47	35.56	5.35	5.62	4.38	3.77	3.03	1.76
1966	65.00	*na*	*na*	*na*	*na*	*na*	*na*	*na*

na Data not available.

FIGURE 49. EXPLORATORY AND DEVELOPMENT DRILLING, WELL-DEPTHS AND PENETRATION RATES 25X1

	1950	1960	1965	1967
Average depth of wells drilled (*meters*):				
Exploratory	1,362	1,928	2,269	*na*
Development	1,148	1,586	1,653	*na*
Drilling rates (*meters/rig/month*):				
Exploratory	208	401	367	380
Development	636	993	1,137	1,107
Total meters drilled (*thousands*)	4,283	7,715	11,291	11,707

na Data not available.

FIGURE 50. OIL AND GAS PRODUCTION BY REGION AND DEPTH, 1966 25X1

REGION	PERCENT OF TOTAL OIL PRODUCTION	DEPTH OF OCCURRENCE IN METERS	PERCENT OF TOTAL GAS PRODUCTION
U.S.S.R.	*100*	....	*100*
Northern regions:			
Urals	*23.2*	2,500–3,000	*11.5*
Povolga	*47.1*	2,000–2,500	
West Siberia	*1.0*	1,000–3,000	*0.5*
Far East	*0.9*	1,800	*0.3*
Southern regions:			
Ukraine	*2.8*	1,250–2,800	*33.6*
North Caucasus	*9.5*	1,300–3,500	*32.8*
Transcaucasus	*9.1*	3,500	*2.5*
Uzbek	*4.1*	500–5,000	*18.0*
Turkmen			*0.3*
Kazakhstan	*1.2*	1,000–3,000	
Ukhta	*1.2*	1,500–1,700	*0.5*

FIGURE 51. PRODUCTION OF CRUDE OIL BY METHOD OF EXTRACTION 25X1
(*Percent of total*)

METHOD OF EXTRACTION	1950	1955	1961	1964	1965	1966	1967
Free-flowing wells	*32.5*	*58.3*	*74.0*	*66.8*	*64.4*	*61.3*	*58.9*
Pump	*44.7*	*34.0*	*23.5*	*30.9*	*33.5*	*36.7*	*39.0*
Compressor gas/air-lift	*21.1*	*6.5*	*2.1*	*1.9*	*1.8*	*1.8*	*1.8*
Other	*1.7*	*1.2*	*.4*	*.4*	*.3*	*0.2*	*0.3*
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

FIGURE 52. REGIONAL COSTS OF SOVIET OIL PRODUCTION AND PREPARING OIL RESERVES, 1966

25X1

REGION	PERCENT OF TOTAL OIL PRODUCTION	AVERAGE DEPTH OF PRODUCING DEPOSITS	COST OF PREPARING 1 TON OF OIL RESERVES	COST OF PRODUCING 1 TON OF OIL
		(*Meters*)	------ *Rubles*	------
U.S.S.R.	*100*	....	38	2.8
Urals	*23*	2,500–3,000	26	2.6
Povolga	*47*	2,000–2,500	36	2.3
North Caucasus	*10*	3,000–3,500	160	4.6
Transcaucasus	*9*	3,500	61	8.0
Central Asia	*4*	2,500	103	9.4
Ukraine	*3*	2,500 2,800	68	2.7
Kazakhstan	*1*	2,000	22	5.3
Ukhta	*1*	1,500–1,700	65	4.2
West Siberia	*1*	2,000	30	4.5
Far East	*1*	1,800	190	9.1

FIGURE 53. ESTIMATED CAPACITIES OF MAJOR SOVIET REFINERIES, 1 JANUARY 1968

25X1

LOCATION OF REFINERY*	NAME	COORDINATES		CAPACITY: PRIMARY DISTILLATION	CAPACITY: SECONDARY (CATALYTIC)
		° ′*N.*	° ′*E.*	------- *Million tons per year*	------
Angarsk	....	52 32	103 57	12	CC—1.2 HT—1.5 HC—U/C
Baku	Waterfront Group (5)	40 23	49 54	20	*na*
	Novo Baku	40 24	49 55	4	2 CC (Thermofor)....0.7 CC (Fluid)....0.35 CC (Fluid)....U/C HT....*na* CR....*na* Alk....0.05
Batumi	....	41 39	41 41	3	*na*
Drogobych	No. 1	49 21	23 33	1	*na*
	No. 2	49 20	23 29	1	*na*
Fergana	....	40 27	71 48	3	CR—*na* HT—*na*
Gorkiy	No. 26	56 20	43 54	1	*na*
	Novo Gorkiy	56 06	44 09	7	CR—*na* HT—*na*
Groznyy	....	43 18	45 39	10	HT—*na*
	Novo Groznyy	43 16	45 37	3	CC—*na* CR—*na*
Guryev	....	47 05	51 56	1	CC (Houdry)....0.2 Alk....0.1
Ishimbay	....	53 26	56 00	2	0
	Novo Ishimbay	53 26	56 02	2	*na*
Khabarovsk	Ordzhonikidze	48 30	135 03	1	0
Kirishi	....	59 29	32 04	6	CR—0.6
Komsomolsk	No. 409	50 37	137 04	1	0
Konstantinovsky	Mendeleyev	57 49	39 37	1	0
Krasnodar	....	45 00	38 58	3	0
Krasnovodsk	....	40 01	52 57	7	CC (Fluid)....0.75 CR....0.6
Kremenchug	....	49 10	33 27	6	CR—0.6

Footnotes are at end of table.

FIGURE 53. ESTIMATED CAPACITIES OF MAJOR SOVIET REFINERIES, 1 JANUARY 196[redacted] (Continued) 25X1

LOCATION OF REFINERY*	NAME	COORDINATES		CAPACITY	
				PRIMARY DISTIL-LATION	SECONDARY (CATALYTIC)
		° 'N.	° 'E.	- - - -	- Million tons per year - - - - - -
Kuybyshev	Lend Lease No. 3	53 06	50 03	5	*na*
	Novo Kuybyshev	53 06	49 55	22	CC (4 Thermofor) 1.8 CR (Hydroformer) 0.3 CR (Platformer) 0.6 Alk 0.05 HT *na* HC Reportedly U/C
Moscow	Lyubertsy	55 39	37 49	4	CR—*na*
Nadvornaya		48 38	24 36	2	*na*
Omsk		55 04	73 13	20	CC—*na* CR—*na* HT—*na* Alk—*na*
Orsk	Lend Lease No. 2 (No. 421)	51 15	58 31	3	CC (Houdry)—0.4
Perm		57 55	36 07	9	CR—*na*
Polotsk		55 32	28 33	12	CR—*na* HT—*na*
Ryazan		54 34	39 45	9	CR—*na*
Salavat		53 25	55 54	8	*na*
Saratov	Kirov	51 27	45 57	6	*na*
Syzran		53 05	48 24	7	CC—*na* CR—*na* HT—*na*
Tuapse		44 07	39 06	3	*na*
Ufa	Staro-Ufimskiy	54 51	56 05	4	*na*
	Novo-Ufimskiy	54 53	56 05	14	3 CC (Thermofor) 1.2 CR (Hydroformer) 0.3 CR (Platformer) *na* Alk 0.3 HT *na*
	Chernikovsk	54 56	56 04	8	CC—*na*
Ukhta		63 34	53 43	1	0
Vannovskiy (Khamzy Khakimzade)		40 26	71 31	2	*na*
Volgograd		48 29	44 37	6	*na*
Yaroslavl		57 33	39 48	12	CC—*na* CR—*na*
Other small plants				3	0
Total				255	

na Data not available.

*See map, Figure 76.

Alk ...... Alkylation.
CC .... Catalytic cracking.
CR ...... Catalytic reforming.
HC ...... Hydrocracking.
HT ..... Hydrogen treating.
U/C ..... Under construction.

FIGURE 54. SECONDARY REFINERY CAPACITY

25X1

SECONDARY PROCESS	CAPACITY: As of 1 January 1966: In percent of primary distillation capacity*	CAPACITY: As of 1 January 1966: Million tons per year	CAPACITY: As of 1 January 1971: In percent of primary distillation capacity**	CAPACITY: As of 1 January 1971: Million tons per year
Hydrogen treating	*6.0*	13.6	*14.0*	42.0
Catalytic reforming	*4.2*	9.4	*8.8*	26.4
Catalytic cracking	*5.3*	11.9	*6.1*	18.3
Coking	*0.8*	1.8	*2.6*	7.8
Urea deparaffination	*0.3*	0.7	*2.1*	6.3
Total	*16.6*	37.4	*33.6*	100.8

*As of 1 January 1966, primary distillation capacity was estimated at 225 million tons.

**As of 1 January 1971, primary distillation capacity is estimated at 300 million tons.

FIGURE 55. ESTIMATED GEOGRAPHIC DISTRIBUTION OF PRIMARY DISTILLATION CAPACITY

25X1

	1958: Million tons	1958: Percent of total	1967: Million tons	1967: Percent of total
Urals-Volga	55	*46.2*	96	*37.7*
Caucasus	38	*32.0*	46	*18.0*
European U.S.S.R. (West and Central) — North	6	*5.0*	54	*21.2*
West Siberia	8	*6.7*	20	*7.8*
Kazakhstan and Central Asia	9	*7.6*	13	*5.1*
East Siberia	0	*0*	12	*4.7*
Ukraine	2	*1.7*	12	*4.7*
Far East	1	*0.8*	2	*0.8*
Total	119	*100.0*	255	*100.0*

FIGURE 56. SOVIET TRADE IN REFINERY EQUIPMENT

IMPORTS			COUNTRY OF ORIGIN							
Year	Total		Rumania		Czechoslovakia		Italy		Other (Unidentified)	
	Quantity*	Value**	Quantity*	Value**	Quantity*	Value**	Quantity*	Value**	Quantity*	Value**
1960	*na*	1,171	*na*	561	0.6	610	0	0	0	0
1961	10.2	9,833	7.1	7,260	3.1	2,573	0	0	0	0
1962	20.9	18,349	13.3	10,051	7.6	8,298	0	0	0	0
1963	22.7	20,300	13.7	10,541	9.0	9,759	0	0	0	0
1964	*na*	20,242	*na*	11,191	*na*	7,521	*na*	1,302	*na*	228
1965	*na*	26,226	*na*	13,458	*na*	9,235	*na*	3,430	*na*	103
1966	*na*	11,140	*na*	850	*na*	6,272	*na*	1,704	*na*	2,314

EXPORTS		COUNTRY OF DESTINATION		
Year	Value**	East Germany	Hungary	Other (Unidentified)
1960	192	160	0	32
1961	444	374	0	70
1962	808	641	0	167
1963	641	97	0	544
1964	1,068	169	831	68
1965	284	148	95	41
1966	163	157	0	6
1967	697	0	0	697

na Data not available.

*Quantity—Thousand of metric tons.

**Value—thousands of rubles (1 ruble=US$1.11).

25X1

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FIGURE 57. ESTIMATED OUTPUT OF PETROLEUM PRODUCTS
(*Millions of tons*)

PRODUCT	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
Gasoline	19.3	21.2	23.0	24.6	26.9	28.9	29.9	31.3	33.6	36.9
Kerosene	14.9	16.2	17.3	18.3	19.6	20.7	21.2	21.7	22.8	24.0
Diesel fuel	21.0	24.3	27.6	31.1	35.5	39.9	42.9	46.7	50.6	55.6
Lubricating oils	3.6	4.0	4.5	4.7	5.3	5.8	6.1	6.6	7.1	7.7
Residuals and others*	32.7	37.1	41.5	45.7	51.7	57.5	61.5	66.1	71.3	78.0
Total	91.5	102.8	113.9	124.4	139.0	152.8	161.6	172.4	185.4	202.2
Total refinery charge	99.5	111.7	123.8	135.2	151.1	166.1	175.7	187.4	201.5	219.8
Gas and loss	8.0	8.9	9.9	10.8	12.1	13.3	14.1	15.0	16.1	17.6

*Primarily heavy fuel oil, but includes asphalt, wax, and petroleum coke.

FIGURE 58. ESTIMATED TRANSPORT OF PETROLEUM, BY TYPE OF CARRIER*

CARRIER	1955				1960				1965			
	Tons carried		Ton-kilometers		Tons carried		Ton-kilometers		Tons carried		Ton-kilometers	
	Million	*Percent*	*Billion*	*Percent*	*Million*	*Percent*	*Billion*	*Percent*	*Million*	*Percent*	*Billion*	*Percent*
Railroads	77.6	*46.6*	101.6	*65.8*	151.0	*45.5*	205.4	*61.3*	222.2	*42.2*	280.4	*42.9*
Pipeline	51.7	*31.0*	14.7	*9.5*	129.9	*39.2*	51.2	*15.3*	225.7	*42.9*	146.7	*22.4*
Inland waterway	14.3	*8.6*	14.3	*9.2*	18.4	*5.5*	18.5	*5.5*	25.0	*4.7*	28.6	*4.4*
Maritime**	23.0	*13.8*	23.9	*15.5*	32.5	*9.8*	60.1	*17.9*	53.5	*10.2*	198.2	*30.3*
Total	166.6	*100.0*	154.5	*100.0*	331.8	*100.0*	335.2	*100.0*	526.4	*100.0*	653.9	*100.0*

*Excludes motor transport.

**Data are for liquid cargos, which are mostly petroleum.

25X1

25X1

FIGURE 59. MAJOR CRUDE OIL AND PETROLEUM PRODUCT PIPELINES COMMISSIONED DURING 1959–67 [redacted] 25X1

ORIGIN	TERMINUS	LENGTH	DIAMETER	SERVICE
		Kilometers	*Inches*	
Friendship pipeline system from Kuybyshev to Eastern Europe.		4,313	20–40	Crude oil.
Including:				
Kuybyshev	Unechka	797	40	*Do.*
Unechka	Mozyr	181	32	*Do.*
Mozyr	Brest	400	24	*Do.*
Mozyr	Uzhgorod	454	24	*Do.*
Unechka	Polotsk	410	28	*Do.*
Polotsk	Ventspils	490	20	*Do.*
Al'met'yevsk	Kuybyshev No. 3	273	32	*Do.*
Kuybyshev	Syzran	140	40	*Do.*
Do	Bryansk*	1,032	20	Product.
Do	Saratov	443	21	Crude oil.
Saratov	Volgograd	575	*na*	*Do.*
Al'met'yevsk	Gorkiy No. 2	577	32	*Do.*
Gorkiy	Yaroslavl' No. 1	375	*est* 28	*Do.*
Gorkiy	Ryazan	415	28	*Do.*
Ryazan	Moscow No. 1	200	*est* 21	*Do.*
Ishimbay	Orsk	324	21	*Do.*
Arlan	Salavat	425	*na*	*Do.*
Salavat	Chernikovsk	188	*na*	Product.
Tuymazy	Omsk No. 2**	1,339	28	Crude oil.
Do	Omsk No. 3	1,339	32	*Do.*
Omsk	Irkutsk	2,401	28	*Do.*
Shaim	Tyumen	410	21	*Do.*
Omsk	Novosibirsk	691	20	Product.
Uzen-Zhetybay	Shevchenko	110	21	Crude oil.
Chelyabinsk	Atbassar	720	*na*	Product.
Kurgan	Atbassar	460	*na*	*Do.*
Tikhoretsk	Tuapse	240	20	Crude oil.
Do	Novorossiysk	240	20	*Do.*
Ali-Bayramly	Baku	134	*na*	*Do.*
Ozek-Suat	Grozny No. 2	200	20	*Do.*

na Data not available.

*Excludes 126 kilometers completed prior to 1959.

**Excludes 156 kilometers completed prior to 1959.

FIGURE 60. SELECTED MAJOR CRUDE OIL AND PETROLEUM PRODUCT PIPELINES SCHEDULED FOR COMPLETION, 1968–75 [redacted] 25X1

ORIGIN	TERMINUS	LENGTH	DIAMETER	SERVICE
		Kilometers	*Inches*	
Tyumen	Omsk	500	20	Crude oil.
Ozek-Suat	Tikhoretsk	700	*na*	*Do.*
Baku	Batumi No. 2	900	28	*Do.*
Al'met'yevsk	Uzhgorod*	4,313	28–40	*Do.*
Aleksandrovsk	Krasnoyarsk	1,300	48–40	*Do.*
Irkutsk	Nakhodka	3,500	28	*Do.*
Uzen	Kuybyshev	1,700	40	*Do.*
Ukhta	Yaroslavl'	1,100	*na*	*Do.*
Okha	Komsomolsk No. 2	624	*na*	*Do.*
Volgograd	Tikhoretsk	500	*na*	*Do.*
Novosibirsk	Chita	2,535	20	Product.
Omsk	Pavlodar	400	20	Crude oil.
Al'met'yevsk	Gorkiy No. 3	577	40	*Do.*
Al'met'yevsk	Gorkiy No. 4	577	*na*	*Do.*
Ryazan	Moscow No. 2	200	*na*	Product.
Perm	Osa	108	20	Crude oil.
Gorkiy	Yaroslavl' No. 2	375	*na*	*Do.*
Yaroslavl'	Kirishi	550	*est* 24	*Do.*
Kirishi	Leningrad	125	*est* 21	Product.
Groznyy	Trudovaya No. 2	879	15	*Do.*
Moscow ring closure		500	*na*	*Do.*

na Data not available.

*Expansion of the Friendship pipeline system.

FIGURE 61. THROUGHPUT CAPACITY AND COST OF TRANSPORTING OIL VIA PIPELINES OF VARYING DIAMETERS

PIPELINE DIAMETER	THROUGHPUT CAPACITY	COST OF TRANSPORTING 1 TON OF OIL/KILOMETER
Millimeters	*Million tons/year*	*Kopecks*
219	0.9	0.220
273	1.5	0.160
325	2.3	0.140
377	3.3	0.130
426	5.0	0.120
529	7.5	0.100
630	11.7	0.075
720	17.0	0.065
820	26.0	0.063
1,020	47.5	0.060
1,220	68.0	*na*

na Data not available.

FIGURE 62. TRANSPORT OF OIL BY RAIL AND INLAND WATERWAY (

YEAR	TONS CARRIED		TON-KILOMETERS		AVERAGE DISTANCE SHIPPED	
	Rail	Inland waterway	Rail	Inland waterway	Rail	Inland waterway
	Million		*Billion*		*Kilometers*	
1950	43.2	11.8	52.0	12.0	1,205	1,018
1955	77.6	14.3	101.6	14.3	1,309	1,001
1958	112.5	16.1	154.0	15.7	1,369	976
1959	132.0	17.5	182.1	17.4	1,380	994
1960	151.0	18.4	205.4	18.5	1,360	1,008
1961	168.4	20.5	230.6	20.6	1,369	1,001
1962	190.5	21.1	252.5	21.1	1,325	997
1963	207.6	22.8	272.5	22.4	1,313	983
1964	219.2	23.9	287.0	25.1	1,309	1,049
1965	222.2	25.0	280.4	28.6	1,262	1,143
1966	240.2	26.9	301.9	30.5	1,257	1,136
1967	260.3	28.6	326.7	*na*	1,255	*na*

na Data not available.

FIGURE 63. SOVIET FOREIGN TRADE IN PETROLEUM (U/OU)
(*Thousands of tons*)

YEAR	EXPORTS			IMPORTS			NET EXPORTS
	Crude oil	Products	Total	Crude oil	Products	Total	
1955	2,916	5,090	8,006	575	3,816	4,391	3,615
1959	12,485	12,887	25,372	1,083	3,339	4,422	20,950
1960	17,825	15,393	33,218	1,166	3,232	4,398	28,820
1961	23,388	17,830	41,218	888	2,736	3,624	37,594
1962	26,279	19,104	45,383	496	2,316	2,812	42,571
1963	30,243	21,139	51,382	543	2,340	2,883	48,499
1964	36,691	19,930	56,621	0	2,082	2,082	54,539
1965	43,432	20,987	64,419	0	1,904	1,904	62,515
1966	50,314	23,318	73,632	0	1,654	1,654	71,978
1967	54,117	24,692	78,809	0	1,359	1,359	77,450

FIGURE 64. ESTIMATED DOMESTIC CONSUMPTION OF PETROLEUM PRODUCTS, BY TYPE OF PRODUCT*

25X1

TYPE OF PRODUCT	1958		1960		1964		1965		1966	
	Million tons	Percent	Million tons	Percent	Million tons	Percent	Million tons	Percent	Million tons	Percent
Gasoline	19.8	*22.8*	22.9	*22.1*	29.2	*19.9*	30.9	*19.6*	33.4	*19.8*
Kerosene	14.7	*16.9*	17.0	*16.4*	22.1	*15.0*	23.0	*14.6*	23.6	*14.0*
Diesel fuel	18.2	*20.9*	23.2	*22.3*	37.0	*25.2*	40.7	*25.8*	44.6	*26.4*
Lubricants	3.4	*3.9*	4.2	*4.0*	6.1	*4.1*	6.5	*4.1*	7.0	*4.2*
Residuals and others**	30.8	*35.5*	36.6	*35.2*	52.6	*35.8*	56.6	*35.9*	60.1	*35.6*
Total	86.9	*100.0*	103.9	*100.0*	147.0	*100.0*	157.7	*100.0*	168.7	*100.0*

*Refinery output plus imports minus exports. Excludes synthetics and natural gas liquids.

**Primarily residual fuel oil.

FIGURE 65. PRODUCTION OF NON-ASSOCIATED NATURAL GAS, BY REGION

25X1

(*Millions of cubic meters*)

REGION	1956	1966
U.S.S.R	8,373	125,173
Komi A.S.S.R	1,000	594
Kuybyshev and Orenburg oblasts	570	658
Bashkir A.S.S.R	0	1,256
Saratov oblast	1,207	6,263
Volgograd oblast	201	6,082
Astrakhan oblast	0	564
Krasnodar kray	308	25,104
Stavropol kray	74	15,733
Dagestan A.S.S.R	11	189
Checheno-Ingush A.S.S.R	98	2
Tyumen oblast	0	565
Sakhalin oblast	112	323
Kharkov oblast	333	29,177
Poltava oblast	17	1,710
Sumy oblast	0	315
Lvov oblast	3,329	8,508
Ivano-Frankovo oblast	0	2,204
Azerbaydzhan S.S.R	1,037	3,068
Uzbek S.S.R	76	22,453
Kirgiz S.S.R	0	155
Turkmen S.S.R	0	151
Tadzhik S.S.R	0	90
Kazakh S.S.R	0	9

FIGURE 66. PRODUCING NATURAL GAS WELLS

25X1

GAS-BEARING REGION	1956		1966	
	Total	Active	Total	Active
U.S.S.R	607	522	2,683	2,343
Komi A.S.S.R	141	124	150	143
Kuybyshev oblast	79	70	100	94
Bashkir A.S.S.R	0	0	22	21
Saratov oblast	138	114	246	185
Volgograd oblast	0	0	261	251
Astrakhan oblast	0	0	24	23
Krasnodar kray	11	11	437	368
Stavropol kray	13	12	239	210
Tyumen oblast	0	0	17	14
Sakhalin oblast	0	0	40	20
Kharkov oblast	7	7	300	277
Poltava oblast	0	0	68	46
Lvov oblast	164	139	271	250
Ivano-Frankovo oblast	0	0	89	72
Azerbaydzhan	0	0	132	82
Uzbek	0	0	209	206
Kirgiz	0	0	12	10
Other regions	54	45	118	112

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FIGURE 67. PLANNED CAPITAL INVESTMENT AND COSTS OF EXTRACTION IN THE NATURAL GAS INDUSTRY, 1971–75 [redacted])

(Rubles per 1,000 cubic meters)

25X1

GAS EXTRACTING REGIONS	AVERAGE CAPITAL INVESTMENT	COST OF EXTRACTION
U.S.S.R.	7.7	0.83
Komi A.S.S.R. (the Vuktyl deposit)	10.0	1.0
Bashkir A.S.S.R.	10.0	0.9
Kuybyshev oblast	28.0	4.6
Orenburg oblast	13.0	1.4
Saratov oblast	8.0	0.8
Volgograd oblast	12.0	1.7
Krasnodar kray	8.9	0.8
Stavropol kray	7.5	0.4
Sakhalin oblast	13.0	1.5
Tyumen oblast	9.0	1.2
Yakutsk A.S.S.R.	10.0	2.1
Western Ukraine	8.0	0.9
Eastern Ukraine	6.7	0.7
Azerbaydzhan	10.0	1.1
Kazakhstan	14.0	1.8
Uzbek	4.2	0.4
Turkmen	10.0	0.9

FIGURE 68. MAJOR NATURAL GAS PIPELINES [redacted]

25X1

YEAR COMPLETED	PIPELINE ROUTE	LENGTH	DIAMETER
		Kilometers	*Inches*
1941	Dashava Lvov	70	8
1943	Bugruslan–Kuybyshev	160	13
	Pokhvinstnevo–Kuybyshev	135	13
	Voy-vozh Ukhta	127	13
1946	Saratov–Moscow	788	13
1948	Kohtla-Jarve Leningrad No. 1 (shale gas)	203	21
	Kohtla-Jarve–Tallinn (shale gas)	141	8
1949	Dashava–Kiev–Bryansk–Moscow	1,300	21
1953	Tuymazy–Ufa	163	13
1954	Tula–Moscow	180	21
	Minnibayevo Kazan No. 1	250	13
1956	Stavropol–Moscow No. 1	1,254	29
1957	Kazan–Gorkiy	378	13
	Shebelinka-Dnepropetrovsk	176	29
1958	Shkapovo-Ishimbay Magnitogorsk No. 1	376	*est* 21
1959	Serpukhov–Leningrad	812	29
	Kohtla Jarve Leningrad No. 2 (shale gas)	203	21
	Stavropol–Nevinomyssk-Groznyy	668	29-21
1960	Stavropol–Moscow No. 2	1,275	33-29
	Dzhar-Kak–Bukhara–Kagan–Samarkand–Tashkent–Chimkent.	1,100	29 21
	Karadag–Akstafa-Yerevan-Tbilisi	770	29-21
	Shebelinka Belgorod Bryansk	873	29
1961	Saratov–Gorkiy–Ivanovo Cherepovets	1,874	33-29-21
1962	Krasnodar-Rostov–Lugansk–Serpukhov	1,890	40-33
	Dashava–Minsk Ivanstevitchi Vilnyus–Riga	1,385	33–29–21
1963	Mozdok–Ordzhonikidze–Tbilisi	380	29–21
	Moscow Ring	414	33
	Minnibayevo Kazan No. 2	282	21
	Kuzyl–Tumshuk–Dushanbe	115	13
1964	Bukhara-Chelyabinsk (Central Asia–Urals No. 1)	1,950	40
1965	Igrim–Serov	507	40
	Bukhara–Nizhnyy Tagil (Central Asia–Urals No. 2)	2,340	40
1966	Serov Nizhnyy Tagil	209	40
	Nizhnaya Tura Perm	364	40
	Ishimbay-Magnitogorsk No. 2	208	*na*

Footnotes are at end of table.

FIGURE 68. MAJOR NATURAL GAS PIPELINES Continued)

25X1

YEAR COMPLETED	PIPELINE ROUTE	LENGTH	DIAMETER
		Kilometers	*Inches*
1967	Bukhara-Moscow-Leningrad (Central Asia-Center) No. 1.	3,200	40
	Poltava-Kremenchug-Krivoy Rog..................	270	40-29
	Dashava-Bratislava, ("Bratsvo" Line)...........	540	29
	Ostrogorzhsk Belousovo..........................	533	40
	Kelif-Mubarek...................................	190	33
	Tas-Tumus-Yakutsk-Pokrovsk......................	300	*est* 21 or 40
	Mubarek Tashkent................................	500	40

na Data not available.

25X1

FIGURE 69. CONSUMPTION OF NATURAL GAS, BY CONSUMING SECTOR

(*Billions of cubic meters*)

CONSUMING SECTOR	1958		1965		1967	
	Consumption	Percent of total	Consumption	Percent of total	Consumption	Percent of total
Industry............	23.9	*85.1*	101.5	*78.4*	133.7	*84.0*
Of which:						
Electric power...	9.6	*34.2*	31.9	*24.6*	41.1	*25.8*
Chemical......	0.3	*1.1*	6.4	*4.9*	9.1	*5.7*
Metallurgy........	1.7	*6.1*	18.1	*14.0*	27.1	*17.0*
Machine building.....	1.8	*6.4*	12.0	*9.3*	17.0	*10.7*
Construction.......	2.4	*8.5*	12.8	*9.9*	16.2	*10.2*
Other..........	8.1	*28.8*	20.3	*15.7*	23.2	*14.6*
Commercial—household...	2.9	*10.3*	17.8	*13.8*	18.2	*11.4*
Other*...............	0.2	*0.7*	6.1	*4.7*	3.0	*1.9*
Gas industry's own needs and losses...........	1.1	*3.9*	4.0	*3.1*	4.3	*2.7*
Total	28.1	*100.0*	**129.4	*100.0*	**159.2	*100.0*

*Includes transport and agriculture.

**Includes 1.6 billion cubic meters of manufactured gas.

FIGURE 70. CONSUMPTION OF NATURAL GAS BY ECONOMIC REGION

25X1

ECONOMIC REGION	1958		1965	
	Billion cubic meters	Percent of total	Billion cubic meters	Percent of total
Ia and b North and Northwest............	1.1	*3.9*	6.3	*4.9*
IV North Caucasus.......................	2.1	*7.5*	11.9	*9.2*
VI Volga................................	4.5	*16.1*	18.5	*14.3*
VII Center..............................	4.8	*16.9*	26.9	*20.8*
VIII Urals..............................	1.3	*4.7*	14.6	*11.3*
XII Far East............................	0.3	*1.1*	0.7	*0.5*
Total R.S.F.S.R.........................	14.1	*50.2*	78.9	*61.0*
II Baltic and Belorussia................	0	*0*	4.1	*3.2*
III South...............................	9.3	*32.9*	32.1	*24.8*
V Transcaucasus.........................	4.4	*15.8*	7.8	*6.0*
X Kazakh S.S.R. and Central Asia........	0.3	*1.1*	6.5	*5.0*
Total U.S.S.R...........................	28.1	*100.0*	*129.4	*100.0*

*Includes 1.7 billion cubic meters of manufactured gas.

25X1

FIGURE 71. UNDERGROUND STORAGE FACILITIES FOR NATURAL GAS [redacted]

SITE	LOCATION	TYPE	CAPACITY		STATUS
			Storage	Withdrawal	
			Million cubic meters		
Kaluga	Southwest of Moscow	Water-bearing sandstone structure.	360	200	Operational.
Shchelkovo	South of Moscow	*do*	2,000	1,000	*Do.*
Gatchina	South of Leningrad	Sloping sandstone formation.	360	175	Testing.
Kolpina	Southeast of Leningrad	Water-bearing sandstone structure.	*na*	*na*	Operational.
Olishevka No. 1	(Chernigov oblast) near Kiev.	Sandstone trap	250	110	Testing.
Krasnopartisan	Near Kiev	Sandstone structure	1,000	400	Under construction.
Inchukalnsk	Near Riga	*do*	3,000	600	*Do.*
Poltoratsk	Near Tashkent	Water-bearing sandstone structure.	1,000	500	Testing.
Novosel'skoye	Near Sverdlovsk	*na*	900	500	Under construction.
Uzynkaragly	Near Alma Ata	Sandstone structure	1,000	300	*Do.*
Elshano-Kurdyum-Peschano-Umet.	Near Saratov	Abandoned gas fields	2,500	1,000	Operational.
Tbilisi	In Georgian S.S.R.	*na*	*na*	400	Under construction.
Apsheron peninsula	Near Baku	Abandoned oil and gas fields.	*na*	*na*	*Do.*
Yerevan	Armenian S.S.R.	Dissolved salt dome	*na*	200	*Do.*
Bashkatov-Amanak	Near Kuybyshev	Abandoned oil and gas fields.	*na*	700	*Do.*
Sakhalin Island	Near Okha	Abandoned oil field	*na*	4.5	Testing.
Ivanovo-Vladimir	Between Moscow and Gorkiy.	*na*	*na*	300	Under construction.
Minsk	Byelorussiya	*na*	*na*	500	Planned.

na Data not available.

25X1

FIGURE 72. NATURAL GASOLINE PLANTS* [redacted]

NAME	LOCATION
In operation:	
Afipskiy	Krasnodar kray.
Baku	Azerbaydzhan S.S.R.
Dolina	Ukrainian S.S.R.
Karabulakskiy	Checheno-Ingush S.S.R.
Karadag	Azerbaydzhan S.S.R.
Korobkovskiy	Volgograd oblast.
Minnebayevo (2)	Kuybyshev oblast.
Neftekumsk	Stavropol kray.
'Otradnyy	Kuybyshev oblast.
Shebelinka	Ukrainian S.S.R.
Shkapova	Bashkir S.S.R.
Siazan	Azerbaydzhan S.S.R.
Under construction or planned:	
Chernushka	Perm oblast.
Duvannyy	Azerbaydzhan S.S.R.
Gazli	Uzbek S.S.R.
Kuleshovka	Kuybyshev oblast.
Mukhanovo	Tatar S.S.R.
Perm	Perm oblast.
Voznesenskiy	Bashkir S.S.R.
Vukhtyl	Komi S.S.R.

*As of 1 January 1968.

FIGURE 73. CONSUMPTION OF LIQUEFIED PETROLEUM GASES, BY CONSUMING SECTOR

(*Thousands of tons*

25X1

YEAR	INDUSTRY			COMMERCIAL-HOUSEHOLD	TRANSPORT	TOTAL
	Petro-chemical	Oil refining*	Other			
1958	15	216	37	40	0	308
1959	43	319	60	81	0	503
1960	319	114	102	125	0	660
1961	544	71	95	240	0	950
1962	768	50	92	340	6	1,256
1963	1,106	76	78	394	7	1,661
1964	1,480	106	147	552	14	2,299
1965	1,760	156	128	732	17	2,793

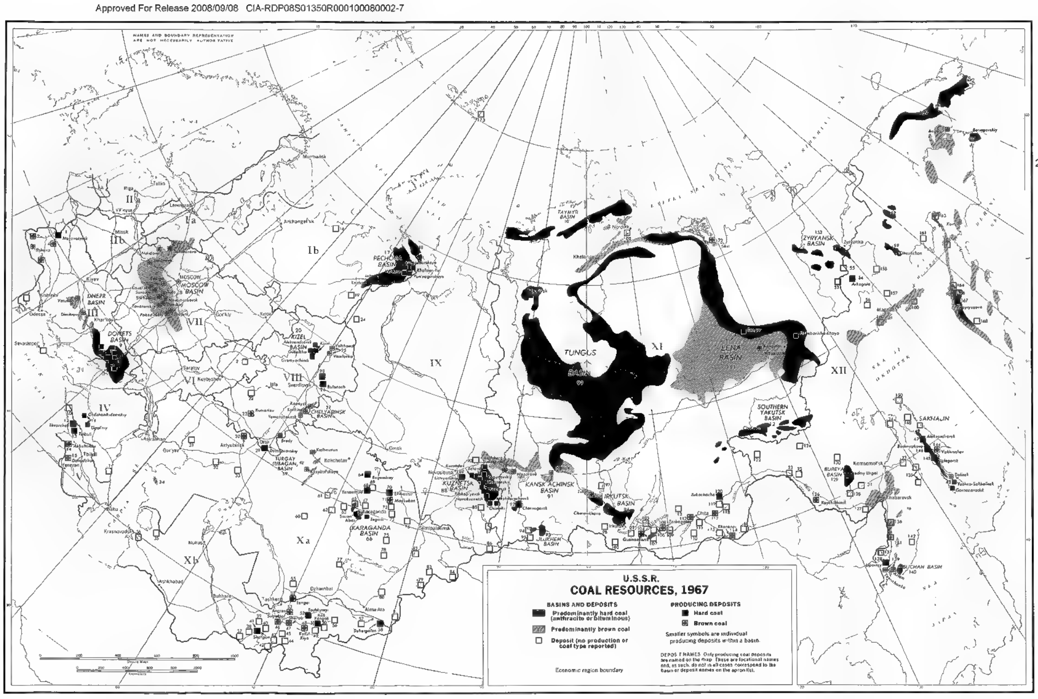
*For production of motor fuel.

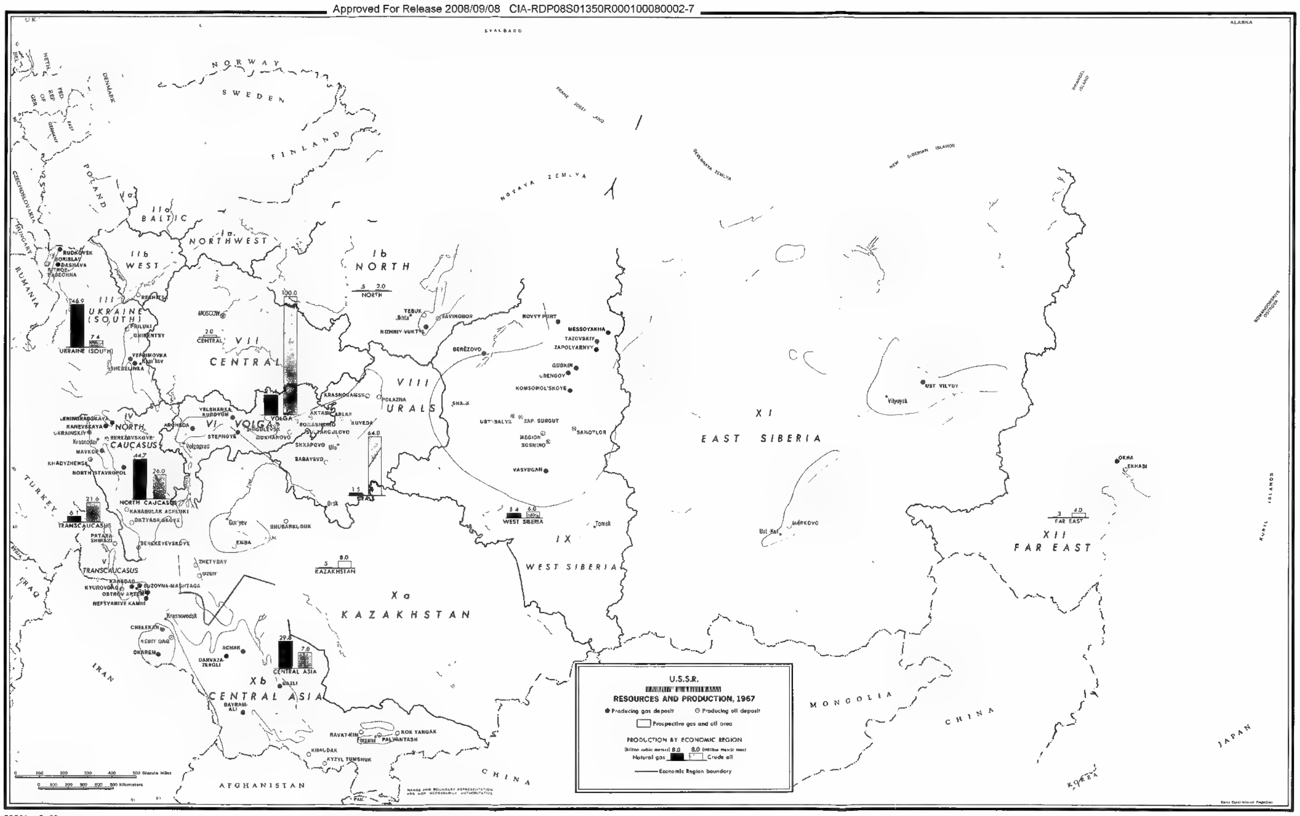
Page Denied

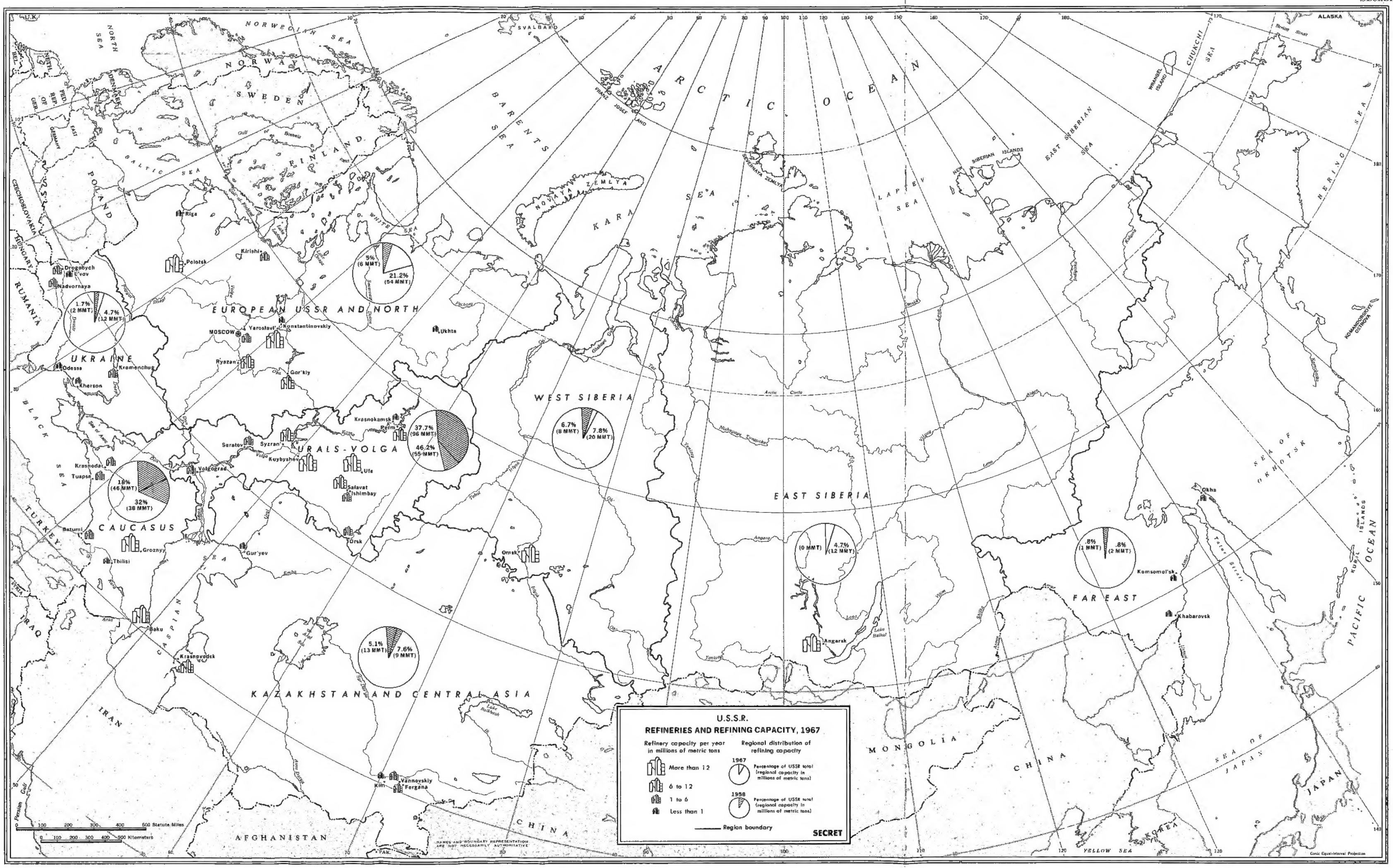
‹MAP—COAL RESOURCES, 1967

COAL DEPOSITS AND BASINS

1 L'vov-Volyn'
2 Transcarpathian
3. Carpathian
4 Dnestr
5. Bolgrad
6. Dnepr Basin
7 Crimean
8. Moscow Basin
9. Donets Basin
10. Northern Caucasus (Carbonaceous)
11 Northern Caucasus (Jurassic)
12. Tkvarcheli
13. Tkibuli
14. Akhaltsikhe
15. Dzhadzhur
16. Timan
17 Pechora Basin
18. Pay-Khoy
19. Shchugor-Buktyl'
20 Kizel Basin
21 Kama Basin
22. Ufa
23. Southern Ural Basin
24. Northern Sos'va
25. Serov (Bogoslovsk
26. Bulanash-Yelkina
27 Chelyabinsk Basin
28. Eastern Urals (Yegorshino, Makhnev, and Poltavo-Bredinskaya
29. Orsk Basin
30 Ural-Caspian Basin
31 Inderborskiy
32 Ural-Emba
33 Berchogur
34. Mangyshlak
35. Tuar-Kyr
36. Balkhan
37 Kugitang
38. Baysun
39 Kshtut-Zauran
40. Fan-Yagnob
41 Shargun
42. Shurabad
43. Ravnouskoye
44. Mionadu
45. Nazarzylok
46. Sulyukta
47 Shurab
48. Kysyl-Kiya
49. Aldyyar
50. Eastern Fergana Basin (Uzgen)
51 Kok-Yangak
52. Tashkumyr
53. Angren
54. Lenger
55. Kara-Tau
56. Kok-Maynak-Karakichi
57 Suguty
58. Dzhergalan
59. Turgay (Ubagan) Basin
60. Dzheskazgan
61-63. Tenghiz-Korpohak
64. Akmolinsk-Kokchetav
65. Zav'yalovo
66. Karaganda Basin
67 Kuu-Chekinsk
68-69. Yeremen'-Tau
70. Ekibastuz
71 Maykyuben'sk
72. Bayan-Aul
73-74. Dzhamanguzsk
75. Bala-Saransk
76. Irtysh
77 Western Balkhash
78. Kemel'bek-Uchkuduk
79. Alakol'
80. Kara-Say Mukri
81 Oy-Karagoy
82. Ayaguz
83 Tarbagatay
84 Zaysan
85. Mulnay
86. Kosh-Agach
87 Altay
88. Kuznetsk Basin
89. Gorlov Basin
90 Tomsk
91. Kansk-Achinsk Basin
92. Minusinsk Basin
93. Ulukhem Basin
94. Ini-Tal
95 Ak-Tal
96. Irkutsk Basin
97 Khakharey
98. Irkutsk River valley
99. Tungus Basin
100 Mouth of the Yenisey
101 Taymyr Basin
102. Baikal
103. Dzhida
104 Gusinoye Ozero
105. Uda valley
106. Tugnuy
107 Khilok
108. Tarbagatay
109. Bada
110. Urey
111 Alengay
112 Chernov
113. Sosnovo-Ozërskoye
114 Kharanor
115. Matsiyev
116. Duroyev
117 Arbagar-Kholbon
118. Delyun
119. Staro-Ola
120. Bukachacha
121. Southern Yakutsk
122. Nyuksha
123. Tolbuzino
124. Upper Zeya
125. Dep-Novoyampol
126. Kivda-Raychikhinsk
127 Ushumun
128. Tyrmin
129 Bureya Basin
130. Ogodzha
131 Urmiysk
132. Khabarovsk
133. Khungari
134. Amgun'-Amur
135. Sovetskaya-Gavan'
136. Bikin
137 Lake Khanka
138. Sufun Basin
139. Uglovoye Basin
140. Suchan Basin
141 Daubikhe
142. Upper Iman
143. Southern Sakhalin
144. Poronay
145. Uglegorsk
146. Krasnogorsk
147 Aleksandrovsk
148. Northwestern Sakhalin
149 Eastern Sakhalin
150. Poluostrov Shmidta
151 Lena Basin
152. Zyryansk Basin
153. Dzhelkansk
154. Arkagala
155. Darpir
156. Chelamdzhinsk
157 Pervomayskoye
158. El'gen
159. Omsukchan
160. Okhotsk
161 Avekova Gizhiga
162. Omolon
163 Penzhino
164. Tigil'
165. Podkagernaya
166. Krutogorovo
167 Khar'yuzovsk
168. Nyapansk
169 Chaun-Chukotsk
170. Anadyr'
171 Beringovskiy
172. Tiksi
173. Nordvik
174. Franz Josef Land




U.S.S.R.
RESOURCES AND PRODUCTION, 1967
Producing gas deposit
Producing oil deposit
Prospective gas and oil area
PRODUCTION BY ECONOMIC REGION
(Billion cubic meters) 8.0
8.0 (Million metric tons)
Natural gas
Crude oil
Economic Region boundary
NORWAY
SWEDEN
FINLAND
POLAND
RUMANIA
TURKEY
IRAN
AFGHANISTAN
CHINA
MONGOLIA
JAPAN
NOVAYA ZEMLYA
ALASKA
KURIL ISLANDS
Ia NORTHWEST
Ib NORTH
II BALTIC
IIb WEST
III UKRAINE (SOUTH)
IV NORTH CAUCASUS
V TRANSCAUCASUS
VI VOLGA
VII CENTRAL
VIII URALS
IX WEST SIBERIA
Xa KAZAKHSTAN
Xb CENTRAL ASIA
XI EAST SIBERIA
XII FAR EAST
MOSCOW
Tomsk



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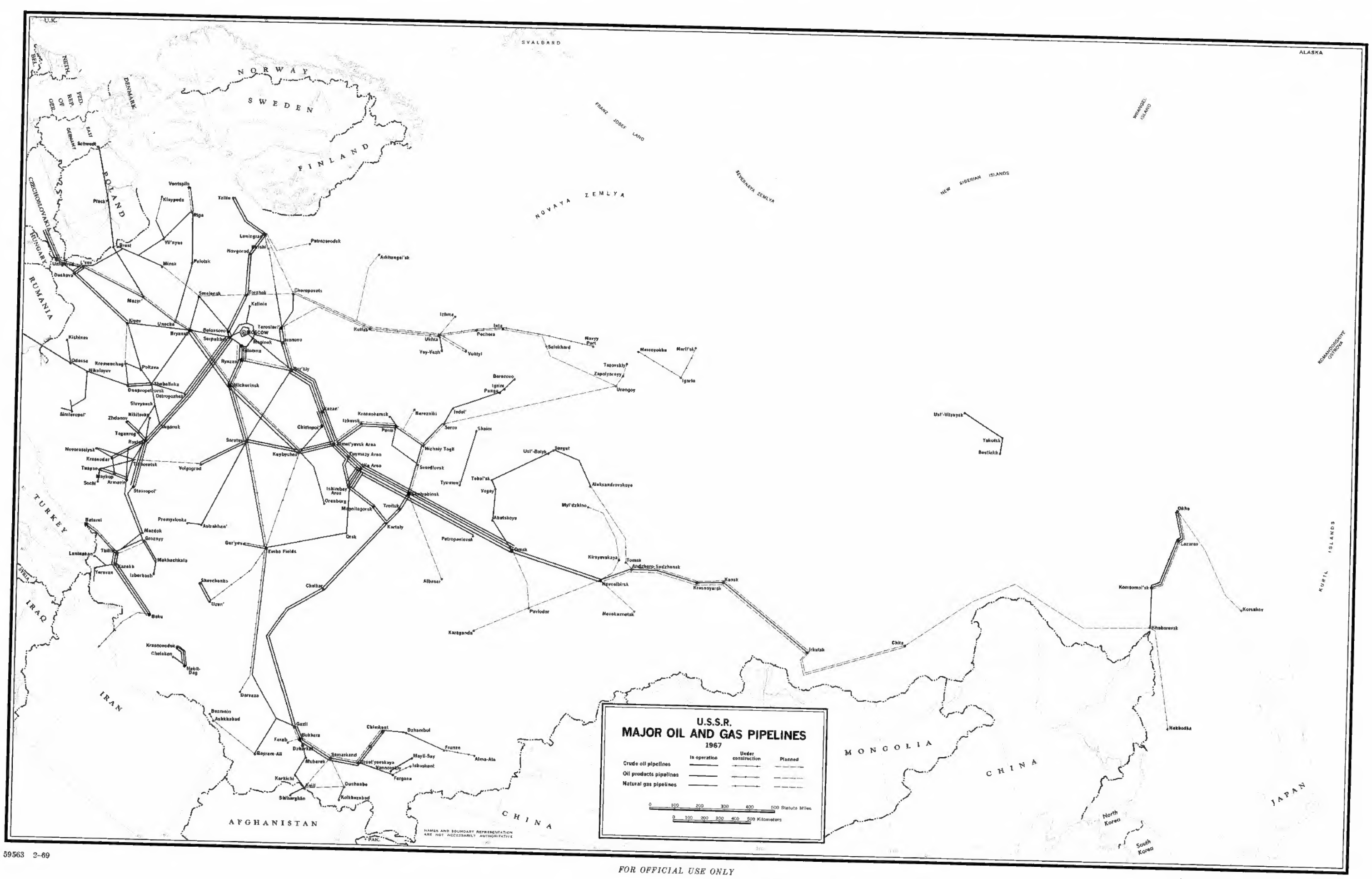

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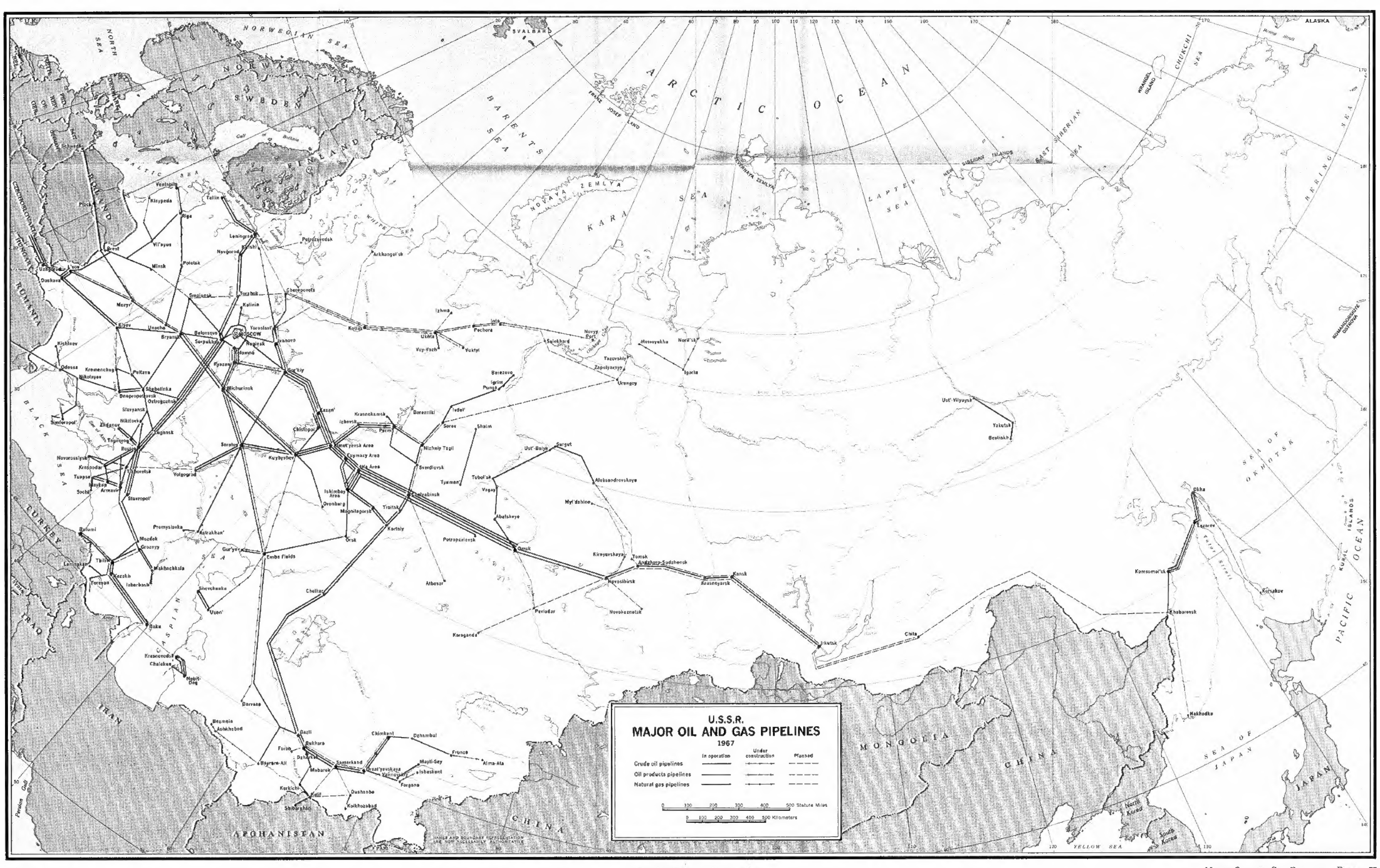
U.S.S.R.
MAJOR OIL AND GAS PIPELINES
1967
In operation
Under construction
Planned
Crude oil pipelines
Oil products pipelines
Natural gas pipelines
Statute Miles
Kilometers
ARCTIC OCEAN
BARENTS SEA
KARA SEA
LAPTEV SEA
EAST SIBERIAN SEA
CHUKCHI SEA
BERING SEA
SEA OF OKHOTSK
PACIFIC OCEAN
SEA OF JAPAN
BLACK SEA
CASPIAN SEA
NORWEGIAN SEA
NORTH SEA
BALTIC SEA
SWEDEN
FINLAND
NORWAY
POLAND
RUMANIA
TURKEY
IRAN
IRAQ
AFGHANISTAN
CHINA
MONGOLIA
JAPAN
ALASKA
Moscow
Leningrad
Kazan'
Perm
Novosibirsk
Omsk
Tomsk
Krasnoyarsk
Kansk
Irkutsk
Chita
Khabarovsk
Nakhodka
Okha
Komsomol'sk
Baku
Tbilisi
Batumi
Groznyy
Makhachkala
Astrakhan'
Volgograd
Stavropol'
Krasnodar
Novorossiysk
Tuapse
Odessa
Kishinev
Minsk
Riga
Vil'nyus
Brest
Polotsk
Bryansk
Kalinin
Yaroslavl'
Gor'kiy
Ryazan'
Michurinsk
Saratov
Kuybyshev
Ufa
Orenburg
Orsk
Chelyabinsk
Sverdlovsk
Tyumen'
Tobol'sk
Surgut
Ust'-Balyk
Aleksandrovskoye
Igarka
Noril'sk
Urengoy
Ukhta
Vuktyl
Pechora
Kotlas
Arkhangel'sk
Cherepovets
Ust'-Vilyuysk
Yakutsk
Bukhara
Samarkand
Tashkent
Alma-Ata
Dzhambul
Chimkent
Fergana
Dushanbe
Krasnovodsk
Pavlodar
Karaganda
Novokuznetsk
Anzhero-Sudzhensk
Kiyevskaya
Mys'dshino
Petropavlovsk
Kurgan
Shaim
Berezovo
Igrim
Punga
Serov
Nizhniy Tagil
Krasnokamsk
Izhevsk
Almetyevsk
Salavat
Ishimbay
Magnitogorsk
Kartaly
Guryev
Emba Fields
Chelkar
Dar'ya
Gazli
Mary
Kerki
Kushka
Shibarghan
Kokand
Kyzyl-Kiya
Nebit-Dag
Cheleken
Mozdok
Kazakh
Yerevan
Iskenderun
Donbass
Kremenchug
Poltava
Shebelinka
Dnepropetrovsk
Ostrogozhsk
Slavyansk
Zhdanov
Taganrog
Rostov
Sochi
Armavir
Tikhoretsk
Uman'
Klaipeda
Ventspils
Tallin
Kirishi
Novgorod
Smolensk
Mozyr'
Kiyev
Unecha
Serpukhov
Orel
Kursk
Voronezh
Penza
Syzran'
Volzhskiy
Zhetybay
Uzen'
Bayramali
Bezmein
Ashkhabad
Shatlyk
Chardzhou
Tol'yatti
Komsomol'sk
Kurile Islands
Sakhalin
Korsakov
North Korea
South Korea
YELLOW SEA